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3600 HEAVY FUEL ENGINES

Maintenance Intervals

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CATERPILLAR

i02304354

Maintenance Interval Schedule

SMCS Code: 1000; 4450; 7500

When Required

Centrifugal Oil Filter - Inspect 81
Cooling System Coolant Sample (Level 2) - Obtain 88
Engine Air Cleaner Element - Replace 92
Engine Crankcase Breather - Clean 96
Engine Oil - Change 99
Engine Oil Filter - Change 101
Fuel - Changeover 111
Fuel Analysis - Obtain 113
Fuel System Primary Filter (Water Separator) Element - Replace 116
Fuel System Secondary Filter - Replace 117
Metal Particle Detector - Inspect 121
Zinc Rods - Inspect/Replace 136

Every Service Hour

Trend Data - Record 130

Daily

Air Starting Motor Lubricator Oil Level - Check 79
Air Tank Moisture and Sediment - Drain 79
Cooling System Coolant Level - Check 86
Driven Equipment - Inspect/Replace/Lubricate ... 92
Engine Air Cleaner Service Indicator - Inspect 95
Engine Air Precleaner - Clean 96
Engine Oil Centrifuge - Check 101
Engine Oil Level - Check 104
Fuel Oil Conditioning Module - Check 114
Fuel Oil Separator - Check 115
Fuel System Fuel Injector Tip Cooling Module - Check 115
Fuel System Primary Filter/Water Separator - Drain 116
Fuel Tank Water and Sediment - Drain 119
Governor Actuator Oil Level - Check 120
Instrument Panel - Inspect 121
Walk-Around Inspection 135

Every Week

Fuel Oil Conditioning Module - Check 114

Every 50 Service Hours or Weekly

Zinc Rods - Inspect/Replace 136

Every 100 Service Hours or 2 Weeks

Turbocharger - Water Wash 134

Every 250 Service Hours

Cooling System Supplemental Coolant Additive (SCA) - Test/Add 88

Every 250 Service Hours or 6 Weeks

Air Shutoff - Test 77
Air Starting Motor Lines Screen - Clean 78
Engine Oil Sample - Obtain 105
Governor Actuator Linkage - Check 119
Oil Mist Detector - Check 122

Every 250 Service Hours or Monthly

Cooling System Coolant Sample (Level 1) - Obtain 87

Every 500 Service Hours or 3 Months

Engine Mounts - Inspect 98
Engine Protective Devices - Check 106
Oil Mist Detector - Clean/Replace 122

Initial 1000 Service Hours or 6 Months

Engine Timing, Synchronization, and Valve Lash - Inspect/Adjust 108
Engine Valve Rotators - Inspect 110

Every 1000 Service Hours

Fuel Oil Conditioning Module - Check 114

Every 1000 Service Hours or 6 Months

Barring Device - Lubricate 80
Cooling System Coolant Sample (Level 2) - Obtain 88
Engine Air Cleaner Service Indicator - Inspect 95
Engine Mounts - Check 97
Engine Oil Filter - Change 101
Exhaust Piping - Inspect 110
Fuel System Primary Filter (Water Separator) Element - Replace 116
Fuel System Secondary Filter - Replace 117
Magnetic Pickups - Clean/Inspect 121
Prelube Pump - Lubricate 129

Every 1500 Service Hours

Fuel Oil Conditioning Module - Check 114

Every 2000 Service Hours or 1 Year

Engine Valve Rotators - Inspect 110
Oil Mist Detector - Clean/Replace 122

Every 2000 Service Hours or 1 Year

Aftercooler Condensation - Drain 76
Engine Timing, Synchronization, and Valve Lash - Inspect/Adjust 108

Every Year

Cooling System Supplemental Coolant Additive (SCA) - Test/Add 88

Every 3000 Service Hours

Fuel Oil Conditioning Module - Check 114

Every 4000 Service Hours or 1 Year

Aftercooler Core - Clean/Test 76
Air Starting Motor Lubricator Bowl - Clean 78
Cylinders - Inspect 91
Exhaust Manifold - Inspect 110
Fuel System Fuel Injector - Clean/Inspect 115
Starting Motor - Inspect 129
Turbocharger Nozzle - Clean 135

Every 8000 Service Hours or 1 Year

Engine Protection Devices - Calibrate 106

Every 8000 Service Hours or 2 Years

Camshaft Roller Followers - Inspect 81
Cooling System Water Temperature Regulator - Replace 89
Crankshaft Vibration Damper - Inspect 90
Driven Equipment - Check 91
Engine Oil Temperature Regulator - Replace 106
Exhaust Shields - Inspect 110
Governor Actuator Oil - Replace 120
Turbocharger - Inspect 133
Water Pump - Inspect 136

Between 8000 and 12 000 Service Hours

Overhaul (Top End) 125
Overhaul Considerations 126

Every 8000 Service Hours or 3 Years

Cooling System Coolant (DEAC) - Change 82
Cooling System Coolant Extender (ELC) - Add 86

Between 16 000 and 24 000 Service Hours

Overhaul (Major) 122
Overhaul Considerations 126

Every 16 000 Service Hours or 6 Years

Cooling System Coolant (ELC) - Change 84

i02348942

Aftercooler Condensation - Drain

SMCS Code: 1063

The aftercooler is similar to a radiator. Coolant passes through the tubes in the aftercooler core. Inlet air that is warmed by the turbocharger compressor is directed through the aftercooler core. The air is cooled in the aftercooler.

Condensation can form in the passages of the aftercooler system. Drain plugs are provided for draining the moisture.

6 and 8 Cylinder Engines

6 and 8 cylinder engines have one drain plug for draining moisture from the aftercooling system.

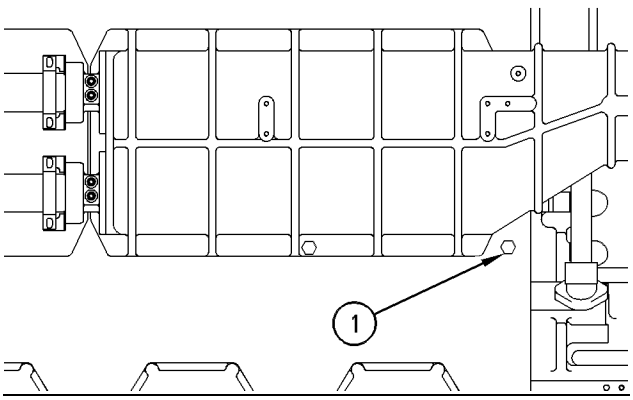

Illustration 60 g00475925

For 6 and 8 cylinder engines, one drain plug is located on the left side near the rear of the engine.

(1) Plug

Note: Prepare a suitable container for the moisture.

1. Remove plug (1).
2. Drain the moisture into a suitable container.
3. Install the plug.

12 and 16 Cylinder Engines

12 and 16 cylinder engines have two drain plugs for draining moisture from the aftercooling system.

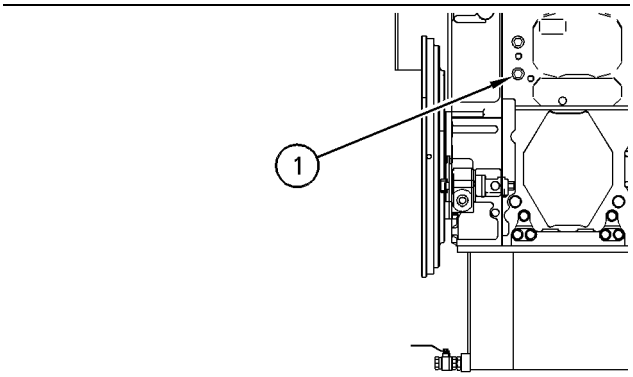

Illustration 61 g00297165

For 12 and 16 cylinder engines, one drain plug is located on the right side near the rear of the engine.

(1) Plug

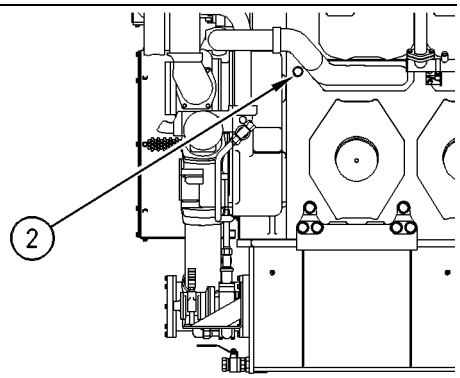

Illustration 62 g00297166

For 12 and 16 cylinder engines, one drain plug is located on the left side near the front of the engine.

(2) Plug

Note: Prepare a suitable container for the moisture.

1. Remove plugs (1) and (2).
2. Drain the moisture into a suitable container.
3. Install the plugs.

i01219706

Aftercooler Core - Clean/Test

SMCS Code: 1064-070; 1064-081; 1064

Before cleaning the aftercooler core, determine if the aftercooler requires cleaning. Use the 152-2067 Differential Pressure Gauge to measure the differential pressure of the air side of the aftercooler. If the differential pressure of the air side is greater than 2 kPa (8 inches of H_2O), clean the aftercooler core.

Cleaning the Aftercooler

See the Service Manual, “Disassembly and Assembly” module for instructions on removal, disassembly, assembly, and installation.

Note: The following procedure may be used for cleaning both the aftercooler core and the oil cooler core.

1. Remove the core. Disassemble the core.
2. Turn the core upside-down in order to remove debris.

NOTICE
Do not use a high pressure spray for cleaning the fins of the core. A high pressure spray can damage the surface of the fins and reduce the flow of air through the core.

NOTICE
Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

3. Back flush the core with cleaner.

   Caterpillar recommends the use of Hydrosolv liquid cleaner. Consult your Caterpillar dealer for the part numbers and quantities that are available.

   Use a two to five percent concentration of the cleaner at temperatures up to 93 °C (200 °F). Refer to Application Guide, NEHS0526 or consult your Caterpillar dealer for more information.

4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.
5. Wash the core with hot, soapy water. Rinse the core thoroughly with clean water.

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

6. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
7. Inspect the core in order to ensure cleanliness. Pressure test the core. Many shops that service radiators are equipped to perform pressure tests. If necessary, repair the core.
8. Install the core.

For more information on cleaning the core, consult your Caterpillar dealer.

i01052568

Air Shutoff - Test

SMCS Code: 1078-081

The air shutoff must operate properly in case an emergency shutdown is needed. Test the operation of the air shutoff. It is not necessary for the engine to be operating in order to test the shutoff.

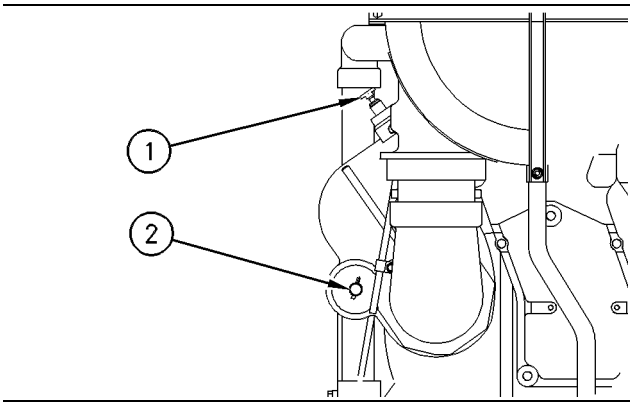

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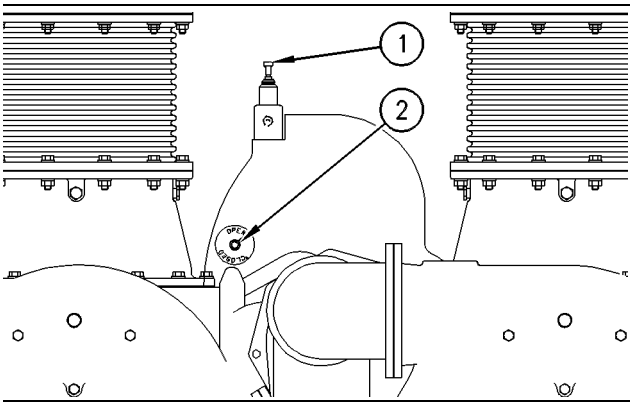
Illustration 63

Air shutoff for in-line engines

(1) Knob
(2) Reset lever



g00545922

Illustration 64

Air shutoff for vee engines

(1) Knob
(2) Reset lever

1. To activate the air shutoff, pull knob (1).

A plate that is inside of the apparatus will cover the air inlet. This prevents air from entering the inlet manifold.

Reset lever (2) should move to the “CLOSED” position. If this fails to occur, investigate the problem. See the Service Manual, “Disassembly and Assembly” topic.

DO NOT operate the engine if the air shutoff will not activate.

Note: The air shutoff must be reset before the engine can be started.

2. To reset the air shutoff, move reset lever (2) to the “OPEN” position.

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Air Starting Motor Lines Screen - Clean

SMCS Code: 1451-070-LI

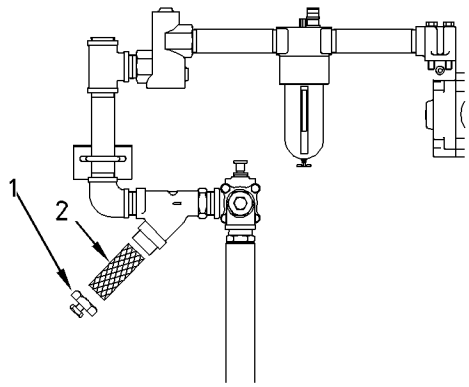


Illustration 65 g00789123

(1) Plug
(2) Screen

If the engine is equipped with an air starting motor, use the following procedure:

1. Ensure that the air supply to the air lines is OFF.

2. Remove plug (1).

3. Carefully remove screen (2). Clean the screen with nonflammable solvent. Inspect the screen for damage. If the screen is damaged, replace the damaged screen with a new screen.

4. Install clean, dry screen (2). Clean plug (1). Install the plug.

i02344769

Air Starting Motor Lubricator Bowl - Clean

SMCS Code: 1451-070

If the engine is equipped with an air starting motor, use the following procedure:

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

1. Ensure that the air supply to the lubricator is OFF.

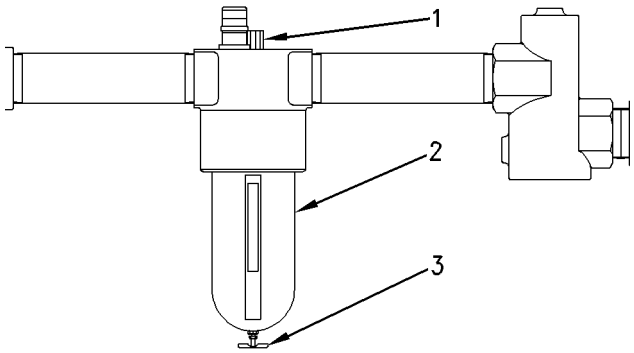


Illustration 66 g00745554

(1) Filler plug
(2) Bowl
(3) Drain valve

2. Slowly loosen filler plug (1) in order to release the pressure from the lubricator.

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

3. Place a suitable container under bowl (2) and open drain valve (3) in order to drain the oil from the bowl.

4. Remove bowl (2). Clean the bowl with warm water.

5. Dry the bowl. Inspect the bowl for cracks. If the bowl is cracked, replace the damaged bowl with a new bowl. Inspect the gasket. If the gasket is damaged, replace the gasket.

6. Install the bowl.

7. Make sure that drain valve (3) is closed.

8. For instructions on filling the lubricator, see this Operation and Maintenance Manual, “Air Starting Motor Lubricator Oil Level - Check” topic.

i02213914

Air Starting Motor Lubricator Oil Level - Check

SMCS Code: 1451-535

NOTICE
Never allow the lubricator bowl to become empty. The air starting motor will be damaged by a lack of lubrication. Ensure that sufficient oil is in the lubricator bowl.

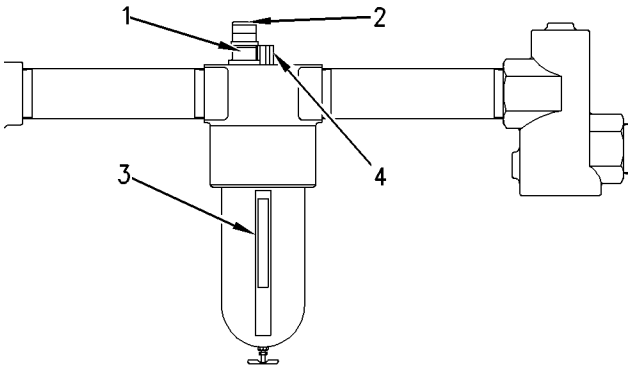


Illustration 67 g00745561

1. Observe the oil level in sight gauge (3). If the oil level is less than 1/2, add oil to the lubricator bowl.

⚠ WARNING

Personal injury can result from removing hoses or fittings in a pressure system.

Failure to relieve pressure can cause personal injury.

Do not disconnect or remove hoses or fittings until all pressure in the system has been relieved.

2. Ensure that the air supply to the lubricator is OFF. Slowly loosen filler plug (4) in order to release pressure from the lubricator bowl.

3. Remove filler plug (4). Pour oil into the lubricator bowl. Use nondetergent SAE 10W oil for temperatures that are greater than 0 °C (32 °F). Use air tool oil for temperatures that are below 0 °C (32 °F).

4. Install filler plug (4).

Adjust the Lubricator

Note: Adjust the lubricator with a constant rate of air flow. After the adjustment, the lubricator will release oil in proportion to variations of the air flow.

1. Ensure that the fuel supply to the engine is OFF.

NOTICE
Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

2. Operate the air starting motor. Observe the drops of oil that are released in dome (1).

Note: Some lubricators have an adjustment screw rather than a knob.

3. If necessary, adjust the lubricator in order to release from one to three drops of oil per second. To increase the rate, turn knob (2) counterclockwise. To decrease the rate, turn the knob clockwise.

i00351324

Air Tank Moisture and Sediment - Drain

SMCS Code: 1466-543-M&S

Moisture and sediment in the air starting system can cause the following conditions:

- Freezing
- Corrosion of internal parts
- Malfunction of the air starting system

⚠ WARNING

When opening the drain valve, wear protective gloves, a protective face shield, protective clothing, and protective shoes. Pressurized air could cause debris to be blown and result in personal injury.

1. Open the drain valve that is on the bottom of the air tank. Allow the moisture and sediment to drain.
2. Close the drain valve.

i02355233

Barring Device - Lubricate

SMCS Code: 1235-086

NOTICE
Do not use an impact wrench to operate the barring device. The use of an impact wrench will cause gear tooth failure.

⚠ WARNING

Guards must be in place prior to operating barring device motor.

Remove all hand tools prior to operating barring device motor.

Note: Prelube of the engine is required before the crankshaft is rotated for normal maintenance.

The barring device provides a means for slowly turning the flywheel in order to service the engine. The barring device can also be used to prevent rotation of the crankshaft. When the barring device is in the engaged position, the engine starting system is disabled.

When the barring device is not used, the barring device must be fully disengaged from the flywheel and secured in the disengaged position. Refer to the Service Manual for information on operation of the barring device.

NOTICE
Do not operate the engine starting motor until the barring group pinion gear is fully disengaged from the flywheel ring gear. Serious damage to the engine could result.

Electric Barring Device

Note: This type of barring device may be electrically driven or manually driven.

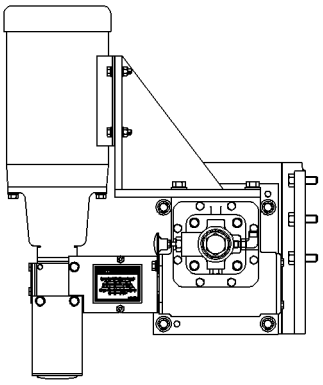


Illustration 68 g00334420

Rear view of an electrically driven barring device

Lubricating the Pinion

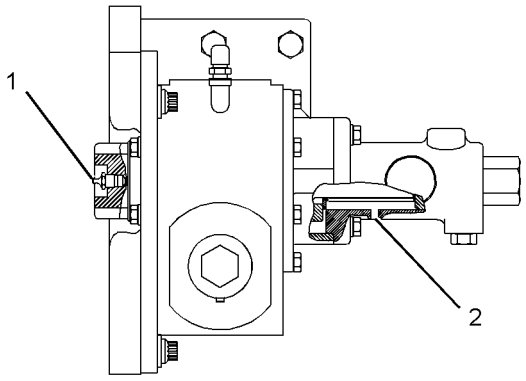


Illustration 69 g01098831

Section view of a barring device without the electric motor

(1) Grease fitting
(2) Vent

1. Ensure that the barring device is locked in the disengaged position.
2. Lubricate grease fitting (1) with Cat Advanced 3Moly Grease until the grease is visible at vent (2).

Lubricating the Reducer

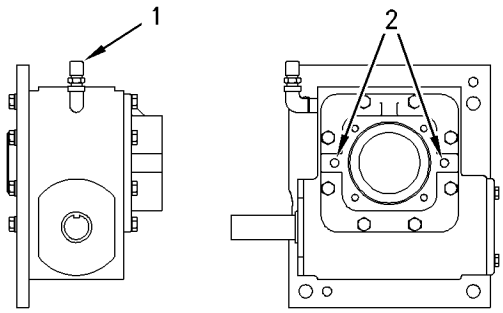


Illustration 70 g00991445

1. Ensure that the barring device is locked in the disengaged position.
2. Remove level plugs (2) and check the lubricant level.
3. If necessary, remove cap (1) and add Caterpillar 4C-6767 Synthetic Oil until the oil is visible at the level plugs.
4. Reinstall the level plugs and reinstall the cap.

Manual Barring Device

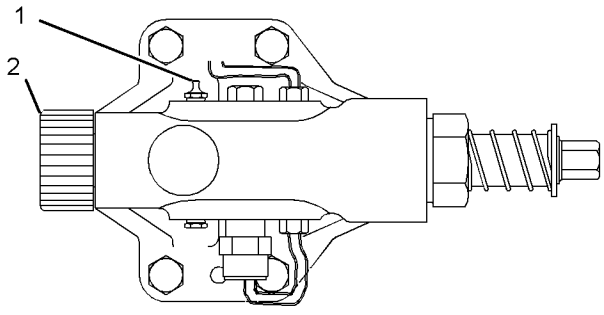


Illustration 71 g01098833

(1) Grease fitting
(2) Gear end

1. Ensure that the barring device is locked in the disengaged position.
2. Lubricate grease fitting (1) with Cat Advanced 3Moly Grease until the grease is visible at gear end (2).

i01904185

Camshaft Roller Followers - Inspect

SMCS Code: 1209-040

For instructions on disassembly and assembly of the valve lifter group, see the Service Manual, “Disassembly and Assembly” module.

Inspect the following components for wear at each metal to metal contact point:

- Rollers for the valve lifters
- Camshaft

Inspect each roller for wear, excessive movement, and end play.

If excessive wear or other signs of deterioration are found, replace the damaged components.

i00449365

Centrifugal Oil Filter - Inspect

SMCS Code: 1328-040

⚠ WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

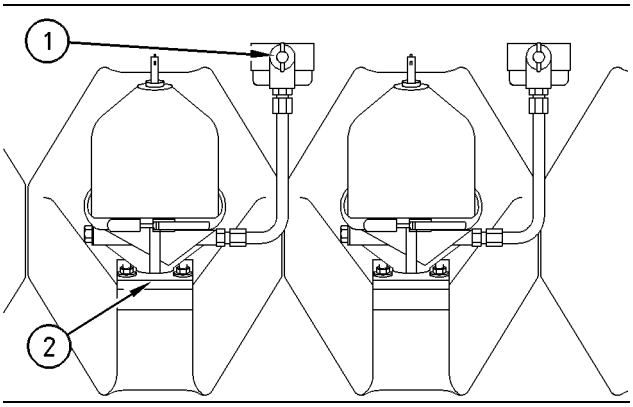


Illustration 72 g00270570

(1) Valve. (2) Base.

Note: If the engine is operating, close valve (1) to the centrifugal oil filter that will be cleaned. Prepare a cover for base (2). The cover will prevent the oil mist from flowing through the orifice in the base.

1. Disassemble the centrifugal oil filter according to the instructions in the Service Manual.

2. Thoroughly clean all of the parts of the centrifugal oil filter. Carefully inspect all of the parts.

3. Measure the clearance between the bearing and the base and measure the clearance between the bearing and the spindle. Follow the instructions that are in the Service Manual. Replace any part that does not meet the specifications that are in the Service Manual.

NOTICE
Ensure that all of the rotor components are thoroughly clean before assembling the rotor. Failure to do so can cause an out of balance condition that can cause rapid wear to the bearings and the spindle.

Note: Install a new paper liner when the centrifugal oil filter is assembled.

4. Assemble the centrifugal oil filter according to the instructions in the Service Manual.

i02305937

Cooling System Coolant (DEAC) - Change

SMCS Code: 1350-044

Clean the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- The coolant is foaming.
- Oil or fuel has entered the cooling system and the coolant is contaminated.

Drain the Cooling System

1. Stop the engine and allow the engine to cool. Ensure that the engine will not start when the cooling system is drained.

2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

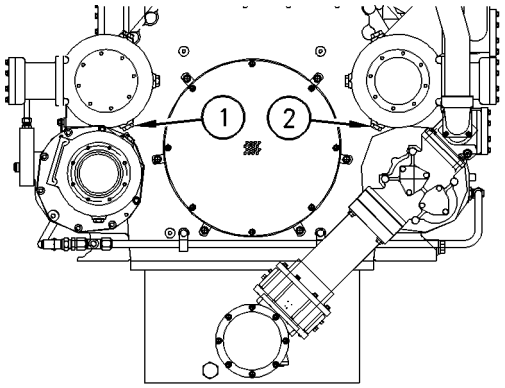


Illustration 73 g00130652

Location of the cooling system drain valves or drain plugs on the water pumps

(1) Jacket water pump
(2) Aftercooler and oil cooler pump

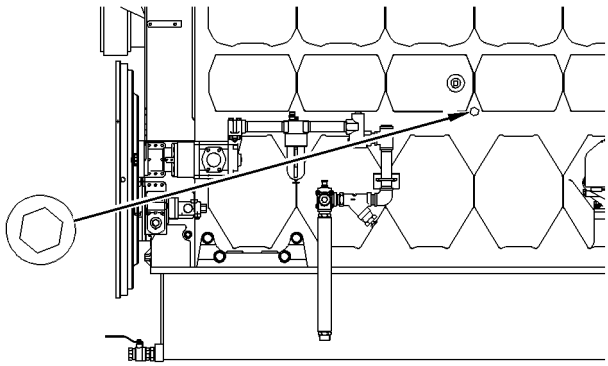


Illustration 74 g00475784

Location of the drain plug (jacket water) for 3606 and 3608 Engines

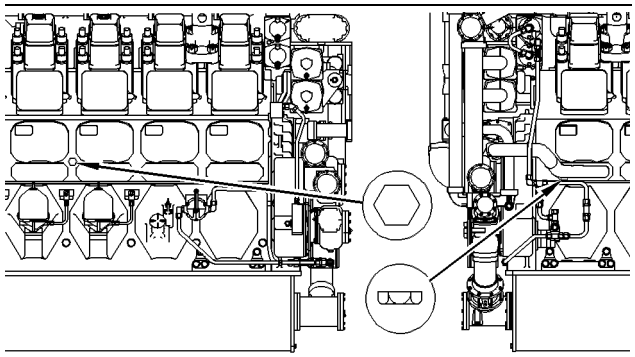


Illustration 75 g00475850

Location of the drain plugs (jacket water) for 3612 and 3616 Engines

3. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Dealer Service Tools Group:

Outside U.S.A.: (309) 675-6277
Inside U.S.A.: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL
CSTG COSA Geneva, Switzerland:
41-22-849 40 56

Clean the Cooling System

NOTICE
Use of commercially available cooling system cleaners may cause damage to cooling system components. Use only cooling system cleaners that are approved for Caterpillar engines.

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 15 L (4 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start the engine. Operate the engine for a minimum of 30 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

Cleaning a Cooling System that has Heavy Deposits or Plugging

Note: For the following procedure to be effective, there must be an active flow through the cooling system components.

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

3. Fill the cooling system with a mixture of clean water and Caterpillar Fast Acting Cooling System Cleaner. Add .5 L (1 pint) of cleaner per 3.8 to 7.6 L (1 to 2 US gal) of the cooling system capacity. Install the cooling system filler cap.

4. Start the engine. Operate the engine for a minimum of 90 minutes with a coolant temperature of at least 82 °C (180 °F).

5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the water to drain.

NOTICE
Improper or incomplete rinsing of the cooling system can result in damage to copper and other metal components.

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

6. Flush the cooling system with clean water until the water that drains is clean. Close the cooling system drain valves (if equipped). Clean the cooling system drain plugs and install the cooling system drain plugs.

Fill the Cooling System

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

Note: For information about the proper coolant to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section). For the capacity of the cooling system, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

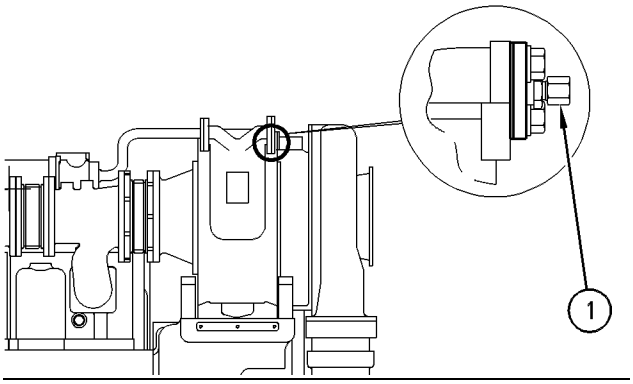


Illustration 76 g00546449
(1) Plug

1. Fill the cooling system with coolant/antifreeze.

   The water lines for the turbochargers must be vented when the cooling system is filled. Remove plug (1). Press a small screwdriver into the check valve in order to vent the line.

   After filling the cooling system, do not install the cooling system filler cap.

2. Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the coolant to warm and allow the coolant level to stabilize. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant to the level that is specified by the OEM of the cooling system.

4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02305948

Cooling System Coolant (ELC) - Change

SMCS Code: 1350-044-NL

Use only clean water to flush the cooling system when Extended Life Coolant (ELC) is drained and replaced.

Drain the Cooling System

1. Stop the engine and allow the engine to cool. Ensure that the engine will not start when the cooling system is drained.

2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

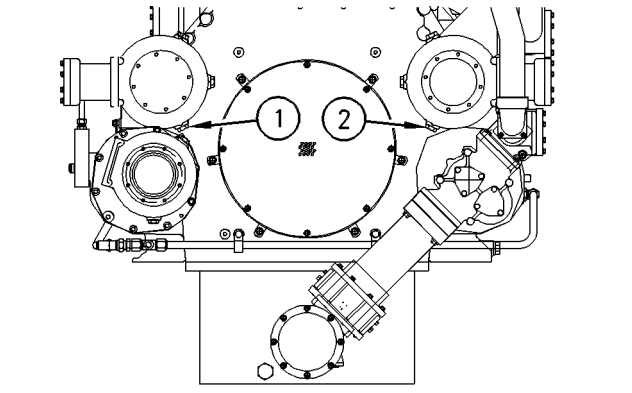


Illustration 77 g00130652
Location of the cooling system drain valves or drain plugs on the water pumps
(1) Jacket water pump
(2) Aftercooler and oil cooler pump

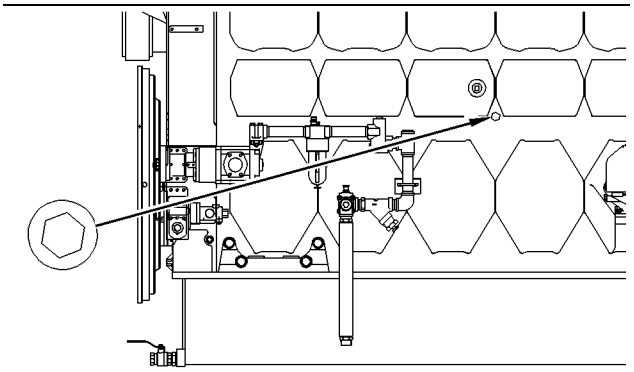


Illustration 78 g00475784

Location of the drain plug (jacket water) for 3606 and 3608 Engines

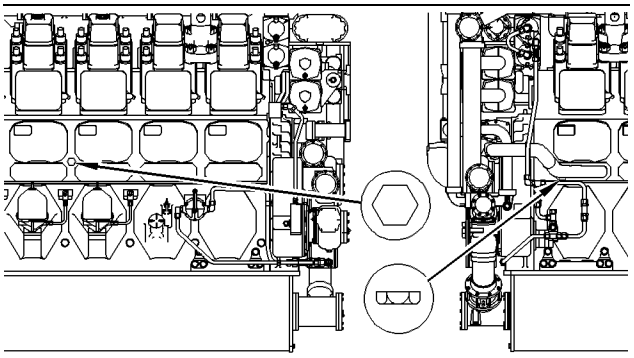


Illustration 79 g00475850

Location of the drain plugs (jacket water) for 3612 and 3616 Engines

3. Open the cooling system drain valves (if equipped). Remove the cooling system drain plugs. Allow the coolant to drain.

NOTICE
Dispose of used engine coolant properly or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Caterpillar to reclaim the used coolant.

For information regarding the disposal and the recycling of used coolant, consult your Caterpillar dealer or consult Caterpillar Dealer Service Tools Group:

Outside U.S.A.: (309) 675-6277
Inside U.S.A.: 1-800-542-TOOL
Inside Illinois: 1-800-541-TOOL
Canada: 1-800-523-TOOL
CSTG COSA Geneva, Switzerland:
41-22-849 40 56

Clean the Cooling System

1. After the cooling system has been drained, flush the cooling system with clean water in order to remove any debris.

2. Close the cooling system drain valves (if equipped). Clean the drain plugs and install the drain plugs.

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

3. Fill the cooling system with clean water. Install the cooling system filler cap. Install the vent plug (4). Operate the engine until the temperature reaches 49 °C (120 °F) to 66 °C (150 °F).

4. Stop the engine and allow the engine to cool. Ensure that the engine will not start when the cooling system is drained. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

5. Open the cooling system drain valves (if equipped). Remove the drain plugs. See Illustration 77. Allow the coolant to drain. Flush the cooling system with clean water. Close the cooling system drain valves (if equipped). Install the drain plugs.

6. Repeat Steps 3, 3, 4, and 5.

Fill the Cooling System

NOTICE
Fill the cooling system no faster than 19 L (5 US gal) per minute to avoid air locks.

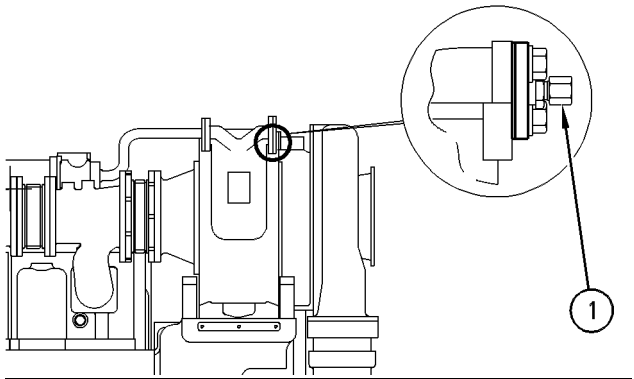


Illustration 80 g00546449

1. Fill the cooling system with Extended Life Coolant (ELC).

The water lines for the turbochargers must be vented when the cooling system is filled. Remove plug (1). Press a small screwdriver into the check valve in order to vent the line.

After filling the cooling system, do not install the cooling system filler cap.

2. Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Allow the ELC to warm and allow the coolant level to stabilize. Stop the engine.

3. Check the coolant level. Maintain the coolant to the proper level on the sight gauge (if equipped). If a sight gauge is not equipped, maintain the coolant within 13 mm (.5 inch) below the bottom of the filler pipe.

4. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets of the cooling system filler cap are damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gaskets of the cooling system filler cap are not damaged, use a 9S-8140 Pressurizing Pump in order to pressure test the cooling system filler cap. The correct pressure is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not maintain the correct pressure, install a new cooling system filler cap.

5. Start the engine. Inspect the cooling system for leaks and for proper operating temperature.

i02285855

Cooling System Coolant Extender (ELC) - Add

SMCS Code: 1352-544-NL

Cat ELC (Extended Life Coolant) does not require the frequent Supplemental Coolant Additive (SCA) additions which are associated with the present conventional coolants. The Extender only needs to be added once.

Check the cooling system only when the engine is stopped and cool.

1. Loosen the cooling system filler cap slowly in order to relieve pressure. Remove the cooling system filler cap.

2. It may be necessary to drain enough coolant from the cooling system in order to add the Extender.

3. Add Extender according to the requirements for your engine's cooling system capacity. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" in the Maintenance Section for more information concerning the Cat ELC Extender additions.

4. Clean the cooling system filler cap. Inspect the gaskets on the cooling system filler cap. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.

i02158408

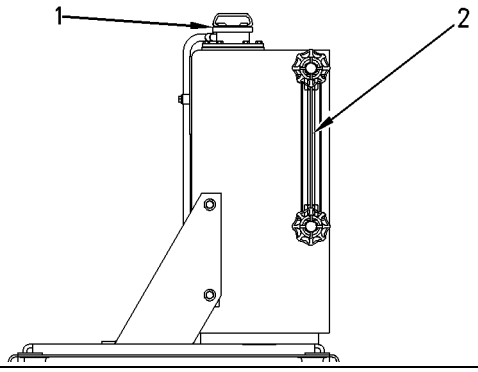
Cooling System Coolant Level - Check

SMCS Code: 1350-535-FLV

WARNING

Climbing equipment may be required to access this service point. Refer to the Operation and Maintenance Manual, "Mounting and Dismounting" topic for safety information.

Engines That Are Equipped With a Sight Gauge



g00750429

Illustration 81

(1) Filler cap
(2) Sight gauge

If the engine is equipped with a sight gauge, observe the position of the coolant in the sight gauge. At normal operating temperature, the proper coolant level is in the upper half of the sight gauge. If the coolant level is low, add the proper coolant mixture.

Engines That Are Not Equipped With a Sight Gauge

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

Check the coolant level when the engine is stopped and cool. Check the coolant level only after the engine has been stopped and the cooling system filler cap is cool enough to touch with your bare hand.

Remove the cooling system filler cap slowly in order to relieve any pressure. Maintain the coolant within 13 mm (0.5 inch) below the bottom of the filler pipe.

Add Coolant

Note: For the proper coolant mixture to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” (Maintenance Section).

1. Stop the engine. Allow the engine to cool.
2. Remove the cooling system filler cap slowly in order to relieve any pressure. Pour the proper coolant mixture into the filler pipe.

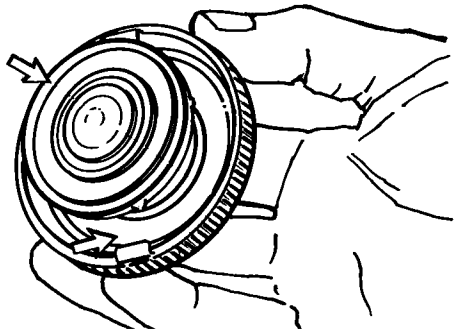


Illustration 82 g00103639

Gaskets

3. Clean the cooling system filler cap. Inspect the gaskets of the cooling system filler cap. If the gaskets are damaged, replace the old cooling system filler cap with a new cooling system filler cap. Install the cooling system filler cap.
4. Start the engine. Inspect the cooling system for leaks.

i02305963

Cooling System Coolant Sample (Level 1) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

NOTICE

Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

For conventional heavy-duty coolant/antifreeze, check the concentration of supplemental coolant additive (SCA) regularly. The concentration of SCA can be checked with an S·O·S coolant analysis (Level 1).

Obtain the sample of the coolant as close as possible to the recommended sampling interval. In order to receive the full effect of S·O·S analysis, you must establish a consistent trend of data. In order to establish a pertinent history of data, perform consistent samplings that are evenly spaced. Supplies for collecting samples can be obtained from your Caterpillar dealer.

Use the following guidelines for proper sampling of the coolant:

- Never collect samples from expansion bottles.
- Never collect samples from the drain for a system.
- Keep the unused sampling bottles stored in plastic bags.
- Keep the lids on empty sampling bottles until you are ready to collect the sample.
- Complete the information on the label for the sampling bottle before you begin to take the samples.
- Obtain coolant samples directly from the coolant sample port. You should not obtain the samples from any other location.
- In order to avoid contamination, immediately place the sample in the tube that is provided for mailing.

Submit the sample for Level 1 analysis.

Note: Level 1 results may indicate a need for Level 2 Analysis.

For additional information about coolant analysis, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” or consult your Caterpillar dealer.

i02354695

Cooling System Coolant Sample (Level 2) - Obtain

SMCS Code: 1350-008; 1395-008; 1395-554; 7542

NOTICE
Always use a designated pump for oil sampling, and use a separate designated pump for coolant sampling. Using the same pump for both types of samples may contaminate the samples that are being drawn. This contaminate may cause a false analysis and an incorrect interpretation that could lead to concerns by both dealers and customers.

Obtain the sample of the coolant as close as possible to the recommended sampling interval. Supplies for collecting samples can be obtained from your Caterpillar dealer.

Refer to Operation and Maintenance Manual, “Cooling System Coolant Sample (Level 1) - Obtain” for the guidelines for proper sampling of the coolant.

Submit the sample for Level 2 analysis.

For additional information about coolant analysis, see the Special Publication, SEBU7003, “3600 and C280 Diesel Engine Fluids Recommendations” or consult your Caterpillar dealer.

i02354713

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

SMCS Code: 1352-045; 1395-081

This maintenance procedure is required for conventional coolants such as DEAC and for mixtures of water and SCA. **This maintenance is NOT required for cooling systems that are filled with Extended Life Coolant.**

⚠ WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and eyes. Do not drink cooling system coolant additive.

Note: Caterpillar recommends an S·O·S coolant analysis (Level 1).

Test the Concentration of the SCA

Coolant/Antifreeze and SCA

NOTICE
Do not exceed the recommended six percent supplemental coolant additive concentration.

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit.

Water and SCA

NOTICE
Do not exceed the recommended eight percent supplemental coolant additive concentration.

Test the concentration of the SCA with the 8T-5296 Coolant Conditioner Test Kit. Use the instructions that follow:

1. Fill the syringe to the “1.0 ml” mark with the coolant.
2. Dispense the 1.0 mL coolant sample from the syringe into the empty mixing bottle.
3. Add tap water to the mixing bottle in order to bring the level up to the “10 ml” mark. Place the cap on the bottle and shake the bottle.
4. Add 2 to 3 drops of the “NITRITE INDICATOR SOLUTION B” to the mixing bottle. Move the bottle in a circular motion in order to mix the solution.
5. Add 1 drop of “NITRITE TEST SOLUTION A” to the mixing bottle. Move the bottle in a circular motion in order to mix the solution.
6. Repeat 5 until the solution changes color from red to light gray, green, or blue. Record the number of drops of “NITRITE TEST SOLUTION A” that were required to cause the color change.
7. Use Table 19 to interpret the results.

Table 19

Number of Drops	Concentration of SCA	Maintenance Required
Less than 25	Less than the recommended concentration of SCA	Add SCA. Retest the coolant.
25 to 30	The recommended concentration of SCA	None
More than 30	More than the recommended concentration of SCA	Remove the coolant. Replace with water only Retest the coolant.

Add the SCA, If Necessary

⚠ WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Remove the cooling system filler cap slowly.

Note: Always dispose of fluids according to local regulations.

2. If necessary, drain some coolant in order to allow space for the addition of the SCA.

NOTICE

Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components.

Excessive supplemental coolant additive concentration could also result in blockage of the heat exchanger, overheating, and/or accelerated wear of the water pump seal.

Do not exceed the recommended amount of supplemental coolant additive concentration.

3. Add the proper amount of SCA. For the proper amount of SCA, refer to this Operation and Maintenance Manual, "Refill Capacities and Recommendations" topic. The proper concentration of SCA depends on the type of coolant that is used. For the proper concentration of SCA, refer to Special Publication, SEBU7003, "3600 and C280 Diesel Engine Fluids Recommendations".

4. Clean the cooling system filler cap. Install the cooling system filler cap.

i02168842

Cooling System Water Temperature Regulator - Replace

SMCS Code: 1355-510

Replace the water temperature regulators for these systems:

- Jacket water
- Oil cooler
- Aftercooler

Replace the water temperature regulators before the water temperature regulators fail. This is a recommended preventive maintenance practice. Replacing the water temperature regulators reduces the chances for unscheduled downtime.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or a seizure of the pistons.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner. Also, a low temperature can allow moisture to condense in the oil. This can form damaging acids.

NOTICE
Failure to replace the water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Never operate an engine without the water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i01983981

Crankshaft Vibration Damper - Inspect

SMCS Code: 1205-040

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

Damage to the crankshaft vibration damper or failure of the damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive gear train noise at variable points in the speed range.

A damper that is hot may be the result of excessive friction. This could be due to misalignment. Use an infrared thermometer to monitor the temperature of the damper during operation. If the temperature reaches 93 °C (200 °F), consult your Caterpillar dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

If a fluid leak is found, determine the type of fluid. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, and smooth.

If the fluid leak is oil, inspect the crankshaft seals for leaks. If a leak is observed, replace all of the seals.

Inspect the damper and repair or replace the damper for any of the following reasons.

- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- The crankshaft bearings are showing excessive wear.
- There is a large amount of gear train wear that is not caused by a lack of oil.

Dampers With Sampling Ports

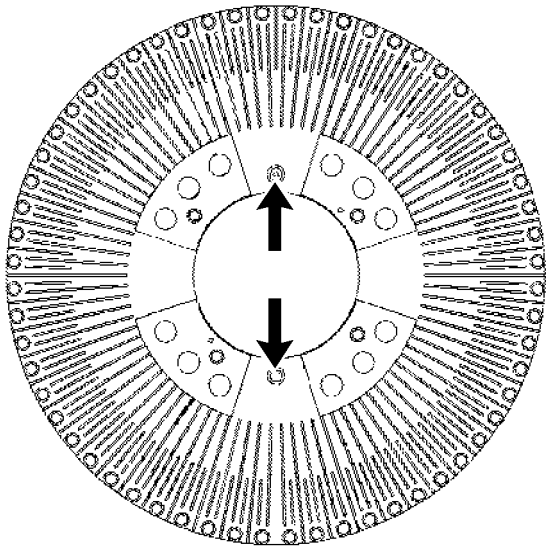


Illustration 83 g00819045

Some dampers have ports for fluid samples. If the damper has no external damage, collect a 2 to 5 mL sample of the damper fluid. The fluid should be analyzed in order to check for a loss of viscosity. Use the results of the analysis to determine if the damper should be rebuilt or replaced. Kits for fluid samples are available from the address that follows. Return the kits to the same address for analysis.

Hasse & Wrede GmbH
Mohriner Allee 30-42
D-12347 Berlin
Germany
Phone: 49 30 / 70 181 195
Fax: 49 30 / 70 09 08-11

Dampers Without Sampling Ports

Some dampers do not have a port for a fluid sample. These dampers must be rebuilt or the dampers must be replaced when one of the following criteria has been met:

- the damper has reached 20,000 hours of operation.

- the engine is undergoing a major overhaul.

Removal and Installation

Refer to the Service Manual or consult your Caterpillar dealer for information about damper replacement.

i01217266

Cylinders - Inspect

SMCS Code: 1223-040; 1223

Use a borescope to inspect the cylinders. The inspection will provide information about the internal condition of the engine.

A borescope with a lens that can be rotated is recommended. This type of borescope provides a clear view of the combustion chamber and of the bottom deck of the cylinder head. Photographic documentation or video documentation is also recommended. Consult your Caterpillar dealer for information on available borescopes.

To perform this procedure, insert the borescope through the cylinder head bores for the fuel injectors. Use the borescope to look for the following conditions:

- Valve wear
- Deposits on the valve face
- Valve seat wear
- Deposits on the valve seat
- Polishing of the cylinder walls
- Scratching of the cylinder walls
- Deposits on the cylinder walls that are above the upper limit of the piston stroke
- Indications of adequate spray patterns (fuel injector) on the piston crowns

Deposits that are on the valve face and the valve seat can cause guttering of the valve face. Inspect the valve seat and the valve face for excessive deposits. If excessive deposits are found, clean the valve and the valve seat or replace the components. Clean the combustion chamber, if necessary.

For information on replacing the components, see the Service Manual. Consult your Caterpillar dealer for assistance.

i00934883

Driven Equipment - Check

SMCS Code: 3279-535

Check the Alignment

To minimize bearing problems and vibration of the engine crankshaft and the driven equipment, the alignment between the engine and driven equipment must be properly maintained.

Check the alignment according to the instructions that are provided by the following manufacturers:

- Caterpillar
- OEM of the drive coupling
- OEM of the driven equipment

Torque all of the fasteners to the proper specifications.

Inspect the Drive Coupling

Inspect the drive coupling according to the instructions that are provided by the OEM of the coupling. For the following service information, see the literature that is provided by the OEM of the coupling:

- Lubrication requirements
- Specifications for the end play
- “Reusability Guidelines”
- Replacement instructions

Inspect the Rear Gear Train

Inspect the crankshaft gear. If excessive wear is found, replace the crankshaft gear and the large cluster idler.

If any gear causes damage to other gears through failure, replace the entire rear gear train.

For the correct parts, see the Parts Manual for the engine. For removal and replacement instructions, see the Service Manual, “Disassembly and Assembly” module. Consult your Caterpillar dealer for assistance.

i00935098

Driven Equipment - Inspect/Replace/Lubricate

SMCS Code: 3279-040

Observe the driven equipment during operation. Look for the following items:

- Unusual noise and vibration
- Loose connections
- Damaged parts

Perform any maintenance that is recommended by the OEM of the driven equipment. Refer to the literature of the OEM of the driven equipment for the following service instructions.

- Inspection
- Lubricating grease and lubricating oil requirements
- Specifications for adjustment
- Replacement of components
- Requirements for ventilation

i00935452

Engine Air Cleaner Element - Replace

SMCS Code: 1051-510; 1054-510

NOTICE
Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent air-borne debris from entering the air inlet.

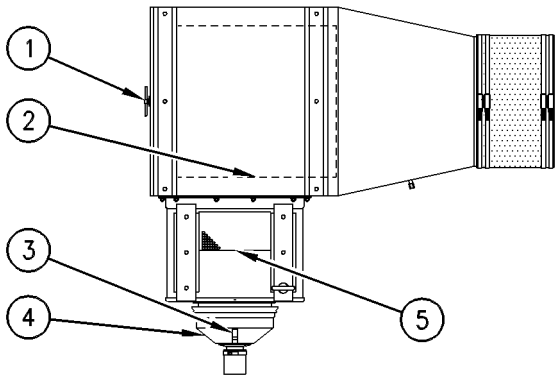
NOTICE
Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

Servicing the Air Cleaner Elements

If the air cleaner element becomes plugged, the air pressure can split the filter material of the element. Unfiltered air will drastically accelerate internal engine wear. Your Caterpillar dealer has the proper air cleaner elements for your application.

- Check the precleaner (if equipped) daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating conditions (dust, dirt and debris) may require more frequent service of the air cleaner element.
- Replace the element when the air restriction reaches 3.75 kPa (15 inches of H_2O).
- Replace the element when the red piston of the service indicator locks in the visible position.
- The air cleaner element may be cleaned up to six times if the element is properly cleaned and inspected.
- Replace the element at least one time per year. Perform this replacement regardless of the number of cleanings.

Replace the dirty paper elements with clean elements. Before installation, thoroughly inspect the element for tears and/or holes in the filter material. Inspect the gasket or the seal of the element for damage. Maintain a supply of suitable elements for replacement purposes.



g00476341

Illustration 84

(1) Access door
(2) Element
(3) Clips
(4) Cup
(5) Screen

1. Open access door (1). Remove element (2).
2. Seal the air inlet to the turbocharger with a cover or tape. This will help to prevent dirt from entering the turbocharger when the body of the air cleaner is cleaned.
3. Loosen clips (3). Remove cup (4). Clean the inside of the cup.
4. Clean screen (5) with pressurized air or water.

5. Use a cloth to clean the inside of the access door and the body of the air cleaner.

6. Install cup (4). Fasten clips (3).

7. Inspect a clean, dry air cleaner element for good condition.

8. Remove the tape or the cover from the air inlet to the turbocharger. Install the air cleaner element.

9. Secure the access door.

10. If necessary, reset the air cleaner service indicator.

Replace the Soot Filter

Some applications use an air silencer that is wrapped in a washable soot filter. The soot filter helps prevent airborne dust and debris from entering the air inlet. As the soot filter becomes dirty, the air restriction increases. Replace the soot filter when the air restriction reaches 3.75 kPa (15 inches of H_2O).

1. Remove the dirty soot filter from the air silencer.

2. Inspect the air silencer. Clean the air silencer, if necessary.

3. Inspect a clean, dry soot filter for good condition. Install the soot filter.

Cleaning the Air Cleaner Elements

The air cleaner element can be used up to six times if the element is properly cleaned and inspected. When the element is cleaned, check the filter material for rips or tears. Replace the element at least one time per year regardless of the number of cleanings.

Use clean elements while dirty elements are being cleaned.

NOTICE
Do not clean the air cleaner elements by bumping or tapping. This could damage the seals. Do not use elements with damaged pleats, gaskets or seals. Damaged elements will allow dirt to pass through. Engine damage could result.

Visually inspect the elements before cleaning. Inspect the elements for damage to the seal, the gaskets, and the outer cover. Discard any damaged elements.

Four methods are used to clean air cleaner elements:

- Pressurized water
- Pressurized air
- Vacuum cleaning
- Washing with nonsudsing detergent

Pressurized Water

Pressurized water will clean the element unless carbon and oil have accumulated on the surface of the element. The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi). Do not use a spray nozzle.

Note: When the element is cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the water flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of water directly at the element. A direct stream of water could cause dirt to be forced into the pleats.

Note: Refer to “Drying the Air Cleaner Elements”. Refer to “Inspecting the Air Cleaner Elements”.

Pressurized Air

Pressurized air can be used to clean elements that have not been cleaned more than two times. Pressurized air will not remove deposits of carbon and oil. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi).

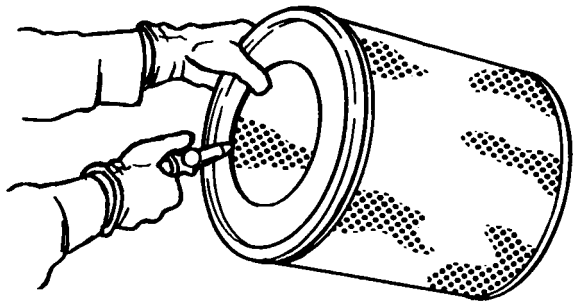


Illustration 85 g00281692

Note: When the elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the hose so that the air flows inside the element along the length of the filter in order to help prevent damage to the paper pleats. Do not aim the stream of air directly at the element. Dirt could be forced into the pleats.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for cleaning elements which require daily cleaning because of a dry, dusty environment. Cleaning with pressurized air is recommended prior to vacuum cleaning. Vacuum cleaning will not remove deposits of carbon and oil.

Note: Refer to “Inspecting the Air Cleaner Elements”.

Washing the Air Cleaner Elements with Nonsudsing Detergent

⚠ WARNING

Do not wash air cleaner elements in any flammable solution such as diesel fuel or gasoline. Doing so can cause fire or an engine runaway and can result in personal injury.

Washing with nonsudsing detergent is effective for cleaning elements that have deposits of carbon or oil. Use a cleaning agent that is specifically manufactured for cleaning air cleaner elements. Cleaning with pressurized water, pressurized air, or a vacuum cleaner is recommended prior to washing with nonsudsing detergent.

1. Place the element into a wash tank so that the gasket is up. The wash tank should be equipped with a rack so that the element does not rest on the bottom of the wash tank.

Note: Caterpillar does not recommend agitating the element. Agitating may cause carbon particles to be distributed.

2. Fill the wash tank with the cleaning agent and warm water to a maximum temperature of 60 °C (140 °F). Follow the manufacturers recommendations for the cleaning agent. Allow the element to soak for six hours.

3. Drain the wash tank. Do not use the cleaning agent more than one time. Remove the element from the wash tank. Rinse the element with the method for using pressurized water.

Note: Refer to “Drying the Air Cleaner Elements”. Refer to “Inspecting the Air Cleaner Elements”.

Drying the Air Cleaner Elements

The oven method may be used in order to dry the elements. If an oven is used, do not expose the elements to temperatures that exceed 82 °C (160 °F).

Note: Do not use compressed air in order to dry the elements.

The elements may be allowed to air dry. Allow two days for the elements to air dry before the elements are inspected and installed.

Inspecting the Air Cleaner Elements

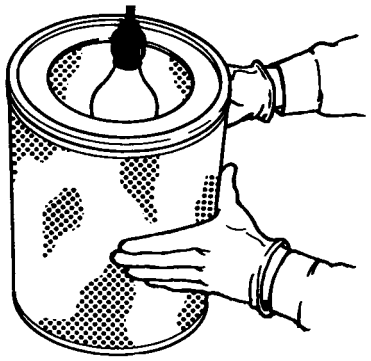


Illustration 86 g00281693

Inspect the clean, dry element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the element. Rotate the element. Inspect the element for tears and/or holes. Inspect the element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the element to a new element that has the same part number.

Do not use an element that has any tears and/or holes in the filter material. Do not use an element with damaged pleats, gaskets or seals. Discard damaged elements.

Storing Air Cleaner Elements

If an element that passes inspection will not be used immediately, store the element for future use.

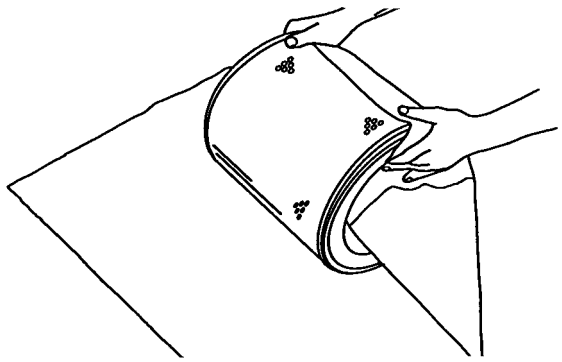


Illustration 87 g00281694

Do not use paint, a waterproof cover, or plastic as a protective covering for storage. Restricted air flow may result. To protect against dirt and damage, wrap the elements in Volatile Corrosion Inhibiter (VCI) paper.

Place the element into a cardboard box for storage. For identification, mark the outside of the container and mark the element. Include the following information:

- Date of cleaning
- Number of cleanings

Store the container in a dry location.

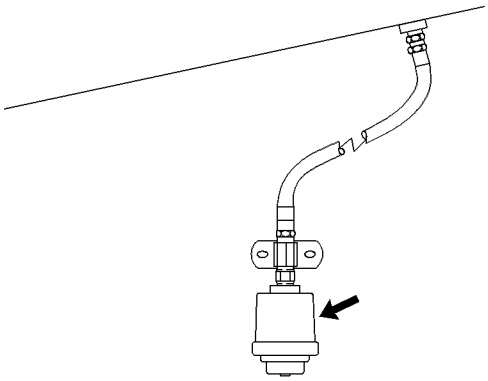
For more detailed information on cleaning the air cleaner element, refer to Special Publication, SEBF8062, “Procedure to Inspect and Clean Air Filters”.

i00935673

Engine Air Cleaner Service Indicator - Inspect

SMCS Code: 7452-040

A service indicator may be mounted on the air cleaner or in a remote location.



g00476444

Illustration 88

Service indicator

Some engines may be equipped with a different service indicator.

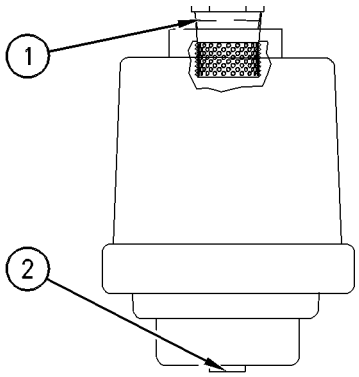
Observe the service indicator. Clean the air cleaner element or replace the element when the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.
- The air restriction reaches 3.75 kPa (15 inches of H_2O).

Inspect the service indicator daily for cracks, holes, or loose fittings. If any of these conditions are present, repair the service indicator or replace the service indicator.

Test the Service Indicator After Every 1000 Service Hours

Service indicators are important instruments. Use the following procedure to verify that the service indicator is operating properly.



g00476445

Illustration 89

(1) Fitting
() Reset button

1. Unscrew the service indicator from fitting (1).

   A porous filter is part of the fitting.

2. Inspect the porous filter for cleanliness. Clean the filter, if necessary. Use compressed air or a clean, nonflammable solvent.

3. Apply vacuum (suction) to the service indicator.

   The yellow diaphragm should enter the red zone and the piston should lock into position. If this does not occur, obtain a new service indicator.

4. Reset the service indicator by pressing reset button (2).

   If the service indicator does not reset easily, obtain a new service indicator.

Note: Excessive force may crack the top of the service indicator.

5. Install the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

The service indicator may need to be replaced frequently in environments that are severely dusty. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

i00935352

Engine Air Precleaner - Clean

SMCS Code: 1055-070

Note: More frequent cleaning may be required in dusty environments.

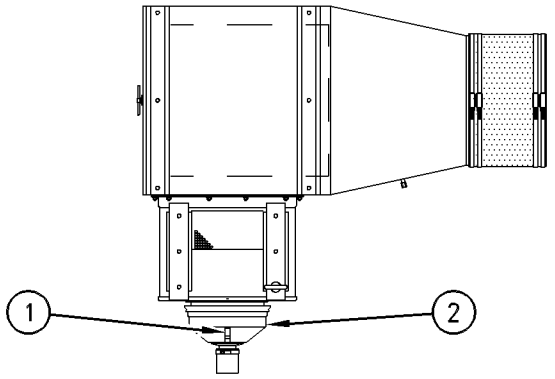


Illustration 90 g00476231

(1) Clip
(2) Cup

1. Loosen clips (1). Remove cup (2).

2. Clean the inside of the cup.

3. Install the cup. Fasten the clips.

i01421692

Engine Crankcase Breather - Clean

SMCS Code: 1317-070

Clean the crankcase breather elements and replace the O-ring seals at every oil change. Perform this maintenance when the engine is stopped.

If the crankcase breather is not maintained on a regular basis, the crankcase breather will become plugged. A plugged crankcase breather will cause excessive crankcase pressure that may cause crankshaft seal leakage.

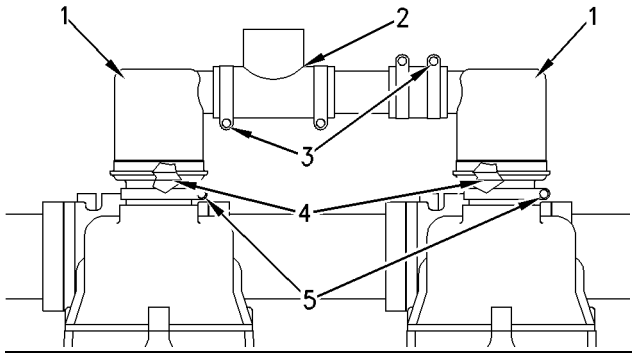


Illustration 91 g00745657

(1) Breather assembly
(2) Tee
(3) Hose clamp
(4) O-ring seal
(5) Retaining clamp

1. Loosen hose clamps (3). Remove tee (2).

2. Loosen retaining clamps (5). Remove breather assemblies (1) and O-ring seals (4).

3. Wash the breather elements in clean nonflammable solvent. Inspect tee (2) for cracks that can be caused by vibration. Replace the old tee with a new tee if cracking is found.

4. Install new O-ring seals (4).

5. Allow the breather elements to dry before installation. Install the breather assemblies in the original position. Coat the rubber parts with clean engine oil or petroleum jelly in order to make installation easier.

6. Install the retaining clamps and the hose clamps. See the Service Manual, “Specifications” module for the proper torque.

i01052365

Engine Mounts - Check

SMCS Code: 1152-535

Measure the Isolators

Spring Type Isolators

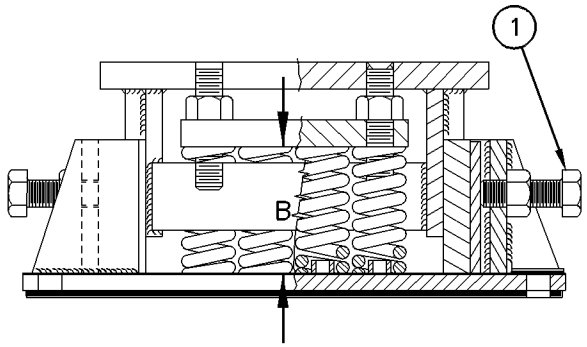


Illustration 92 g00545733

7C-0533 Generator Base Mounting Group

(1) Snubber bolt

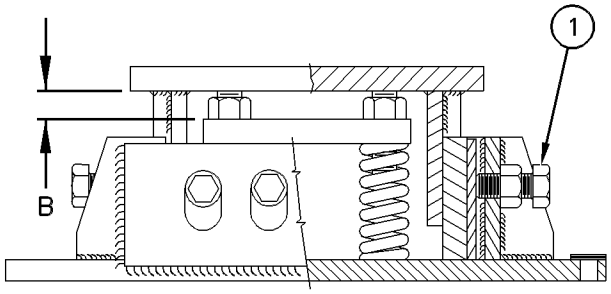


Illustration 93 g00545734

7C-6537 Generator Base Mounting Group

(1) Snubber bolt

Obtain dimension (B) for each isolator. If any of the following conditions are found, adjust the isolators:

- Dimension (B) is different from the original dimension that was obtained during the engine commissioning.
- Dimension (B) is not within 3 mm (.12 inch) for all of the isolators.
- Snubber bolts (1) are not finger tight against the plates.

For instructions on adjustment, see Special Instruction, SEHS9162, “Spring Isolator Group Installation and Adjustment Procedure”.

Resilient Isolators

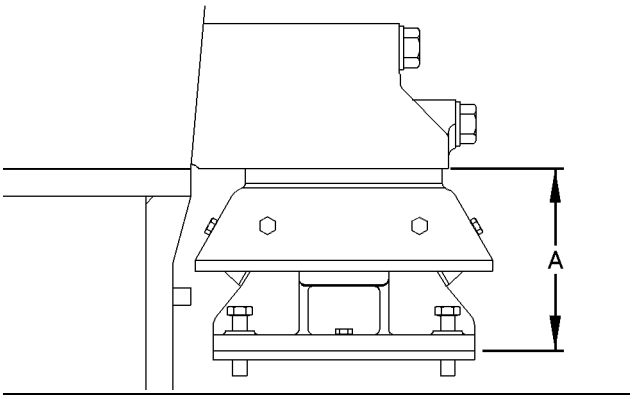


Illustration 94 g00270544

(A) Dimension between the top of the soleplate and the bottom of the engine support assembly.

Measure the loaded height of each isolator. Use an inside micrometer and measure dimension (A) between the top of the soleplate and the bottom of the engine support assembly. Measure each corner of each isolator in order to ensure that the top and the bottom of each isolator is parallel. The four measurements for each isolator should not differ by more than 0.5 mm (.02 inch).

Compare the measurements to the specifications from the engine commissioning. Adjust the height of the engine support assembly in order to maintain the specifications for alignment.

Adjust the Height Of the Engine Support Assembly, If Necessary

Note: When shims are used in order to maintain the height of the engine support assembly, the alignment of the engine and the driven equipment must be verified.

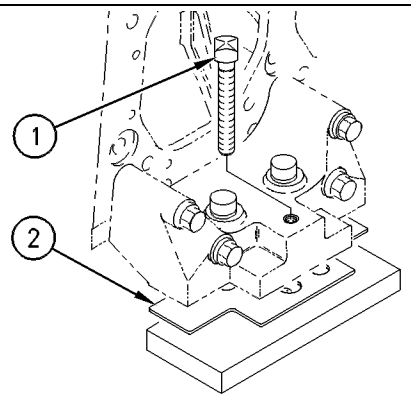


Illustration 95 g00270557

(1) Setscrew. (2) Shim.

To adjust the height of the engine support assembly, use setscrew (1). To raise the height of the engine support assembly, add shims (2). To reduce the height of the engine support assembly, remove shims (2).

Maintain a record of all of the shims that are added from the time of the engine commissioning. When the combined total of the shims that are added to any isolator exceeds 5 mm (.2 inch), the isolator must be repaired or replaced.

i01421709

Engine Mounts - Inspect

SMCS Code: 1152-040; 1152

Inspect the condition of the isolators. The isolators must be kept clean and dry. Ensure that the isolators are free of oil and contamination.

Resilient Isolators

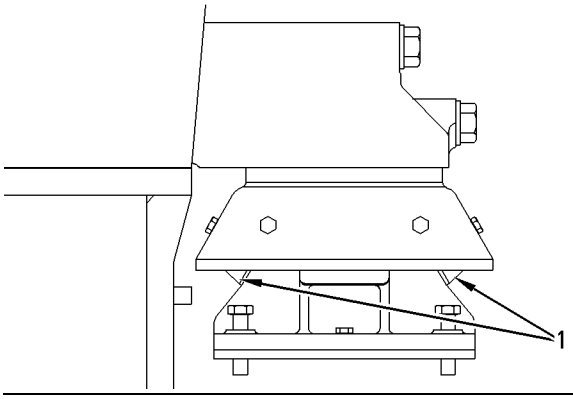


Illustration 96 g00745665

(1) Rubber element

Each isolator has four rubber elements. The most usual cause for failure of the isolator is oil contamination of the rubber elements. Inspect the rubber elements of each isolator for the following conditions.

- Swelling
- Blistering
- Cracking

Perform the following procedures when deterioration of the rubber elements is initially observed:

- Record the observation in a log.
- Check the alignment of the driven equipment.

After deterioration of the rubber elements is initially observed, the rubber elements must be carefully inspected. Any further deterioration of the rubber elements must be recorded. The isolator must be repaired or replaced if rapid deterioration of the rubber elements is observed.

Deterioration of the rubber elements is usually accompanied by settling of the isolator. Settling of the isolator will result in misalignment between the engine and the driven equipment.

Check the Center Bolt

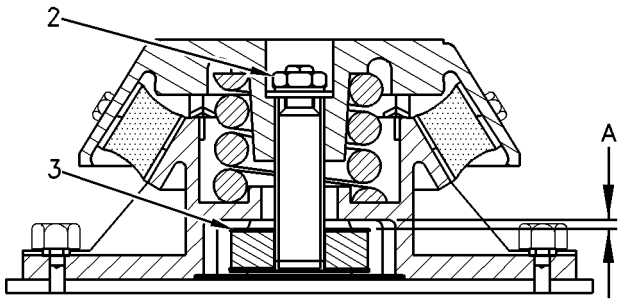


Illustration 97 g00745664

(2) Locknut
(3) Adjustable assembly
(A) Clearance above the adjustable assembly

Check the tightness of locknut (2) on the center bolt. Use a minimum torque of 100 N·m (75 lb ft).

If locknut (2) is loose, perform the following Steps:

1. Tighten locknut (2) to 140 N·m (105 lb ft).
2. Measure clearance (A) above adjustable assembly (3).

3. Compare the clearance to the specification from the engine commissioning. The clearance and the specification from the engine commissioning must be equal.

Any difference in the dimension indicates that the height of the isolator has changed. A change in the height of the isolator will result in misalignment between the engine and the driven equipment.

i02306014

Engine Oil - Change

SMCS Code: 1348-044; 1348

Oil Change Interval

Considerations for the oil change interval include the type of fuel and the engine application. The establishment of an S·O·S oil analysis program will enable an evaluation of the used oil. The evaluation can be used to determine the oil change interval that is suitable for your specific engine. Change the engine oil when oil analysis determines that the oil has reached the condemning limit.

In the absence of oil analysis, change the engine oil according to the interval that is listed in Table 20.

Table 20

Oil Change Intervals For 3600 Engines (Heavy Fuel Oil)		
Engine	**Lube Oil Capacity**(1)	**Oil Change Interval**(2)
Industrial Engines and Generator Set Engines		
3606	880 L (229 US gal)	700 Service Hours
3608	1112 L (289 US gal)	650 Service Hours
3612	1302 L (339 US gal)	500 Service Hours
3616	1677 L (443 US gal)	500 Service Hours
Marine Engines (Zero Degree Tilt)		
3606	731 L (190 US gal)	500 Service Hours
3608	795 L (207 US gal)	450 Service Hours
3612	943 L (245 US gal)	400 Service Hours
3616	1091 L (284 US gal)	300 Service Hours

(1) The capacity includes the oil sump plus oil filters that are installed at the factory. Engines with auxiliary oil filters will require additional oil. The capacity is approximate. The actual capacity may vary by five percent. Caterpillar recommends using the capacity that is listed and then adjusting the oil level according to the oil level gauge (dipstick).

(2) Use this oil change interval in the absence of oil analysis.

Change the Engine Oil

WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed when the cold oil is drained. Drain the crankcase with the oil warm. This method allows the waste particles that are suspended in the oil to properly drain.

Failure to follow this recommended procedure will allow the waste particles to be recirculated through the engine lubrication system with the new oil.

1. After the engine has been operated at normal operating temperature, STOP the engine.

NOTICE
Ensure that the engine is stopped before performing this procedure. Attach a DO NOT OPERATE tag to the starting controls.

Note: Drain the oil into a suitable container. Dispose of fluids according to local regulations.

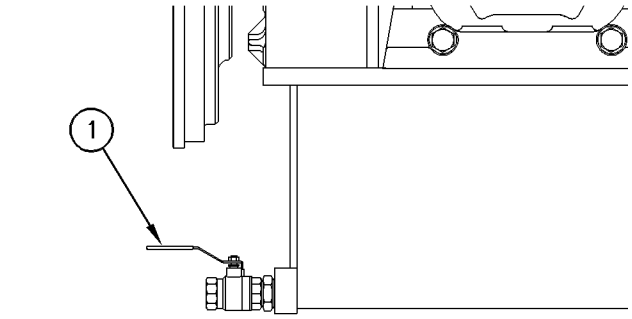


Illustration 98 g00130760
(1) Drain valve

2. Open drain valve (1) in order to drain used oil. After the oil has drained, close drain valve (1).

Note: If a suction device is used in order to remove the oil from the oil pan, ensure that the suction device is clean. This will prevent dirt from entering the oil pan. Be careful not to strike the engine oil suction tubes or the piston cooling jets.

3. Clean the oil suction screen.

Note: Approximately 1 L (1 qt) of oil will remain in the housing after the sump has been completely drained. This oil will pour out of the housing when the cover for the oil suction screen is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with absorbent towels or pillows. DO NOT use absorbent particles to clean up the oil.

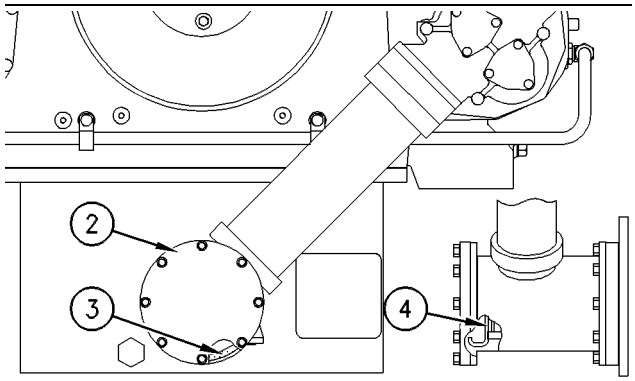


Illustration 99 g00540945
(2) Cover
(3) Seal
(4) Screen

a. Remove cover (2) and seal (3). Discard the used seal. Slide screen assembly (4) from the tube.

b. Wash the screen assembly in clean nonflammable solvent. Allow the screen assembly to dry before installation.

4. Clean the bottom of the sump. Remove side covers in order to gain access to the sump. When the bottom of the sump is clean, install the side covers.

5. Install the oil suction screen. Install the cover and a new seal.

6. Change the engine oil filters. See this Operation and Maintenance Manual, “Engine Oil Filter - Change” topic (Maintenance Section).

7. Clean the centrifugal oil filters.

a. Disassemble the centrifugal oil filters according to the instructions in the Service Manual.

b. Thoroughly clean all of the parts of the centrifugal oil filter. Carefully inspect all of the parts.

NOTICE
Ensure that all of the rotor components are thoroughly clean before assembling the rotor. Failure to do so can cause an out of balance condition that can cause rapid wear to the bearings and the spindle.

Note: Install a new paper liner when the centrifugal oil filter is assembled.

c. Assemble the centrifugal oil filters according to the instructions in the Service Manual.

NOTICE
Only use oils that are recommended by Caterpillar. For the proper oil to use, refer to this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section).

NOTICE
Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil’s ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

8. Remove the oil filler cap. Fill the crankcase through the oil filler tube only. Clean the oil filler cap. Install the oil filler cap.

9. Start the engine according to this Operation and Maintenance Manual, “Engine Starting” topic (Operation Section).

   a. Operate the engine at low idle for two minutes. Inspect the engine for oil leaks.

   b. Ensure that the oil level is at the “FULL” mark on the “LOW IDLE” side of the oil level gauge.

10. Stop the engine and allow the oil to drain back into the sump for a minimum of ten minutes.

11. Remove the oil level gauge and check the oil level. Maintain the oil level to the “FULL” mark on the “ENGINE STOPPED” side of the oil level gauge.

i00936366

Engine Oil Centrifuge - Check

SMCS Code: 1348-535

Heavy fuel oil introduces higher levels of combustion products into the crankcase than distillate fuel. A centrifugal separator (centrifuge) is used for cleaning the engine oil. This cleaning extends the service life of the oil.

The engine oil must be cleaned by this method at least one time during each eight hours of operation.

The lubrication systems of several engines can be serviced by a single centrifuge of sufficient size. However, mixing the oils can spread contaminants between the engines. This will produce inaccurate results from oil analysis. Therefore, the oil from each engine must be processed in rotation. This will help to prevent mixing the oils from different engines.

- For each engine, operate the centrifuge for the engine oil at least one time during each eight hours of engine operation.
- Check the centrifuge according to the instructions that are provided by the OEM of the centrifuge. See the engine’s Technical Manual.
- Perform the maintenance and service activities that are described in the literature.

i00936346

Engine Oil Filter - Change

SMCS Code: 1308-510; 1308

Replace the engine oil filters when the following conditions are met:

- Every oil change
- The engine oil filter differential pressure reaches 100 kPa (15 psi).
- The oil filters have been used for 1000 service hours or six months.

Note: Do not attempt to clean the used oil filters. Used oil filters will retain waste particles. The used oil filters would not filter the oil properly.

Service tools are available to aid in the service of oil filters. Consult your Caterpillar dealer for the part names and the part numbers. Follow the instructions that are supplied with the service tools. If the service tools are not used, perform the following appropriate procedure.

Replacing the Engine Oil Filters With the Engine Stopped

⚠ WARNING

Hot oil and components can cause personal injury.

Do not allow hot oil or components to contact skin.

Perform the following procedure after the oil has been drained.

Note: Use this procedure if the engine oil filters do not have a control valve.

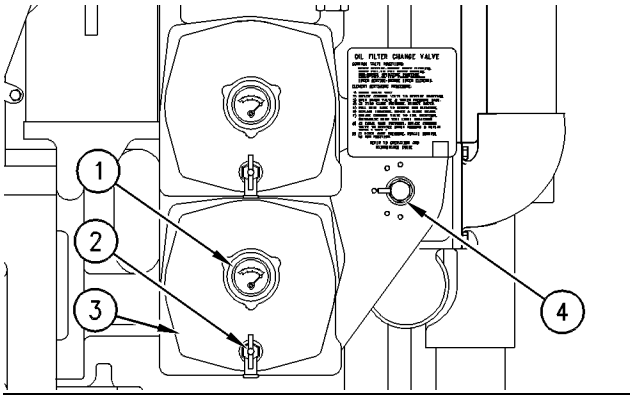


Illustration 100 g00296711

(1) Pressure gauge
(2) Drain
(3) Cover
(4) Control valve

1. Connect a hose from each drain valve (2) to a suitable container in order to catch the oil.

2. Open both drain valves (2). Allow the oil to drain.

Note: Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (3) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with rags. DO NOT use absorbent particles to clean up the oil.

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

3. Be alert to the spring force. The cover has a spring force up to 240 N (54 lb). Gradually loosen but do not remove the last two bolts or nuts that are located at opposite ends of covers (3). Before removing the last two bolts or nuts, pry the covers loose or tap the covers with a rubber mallet in order to relieve any spring pressure.

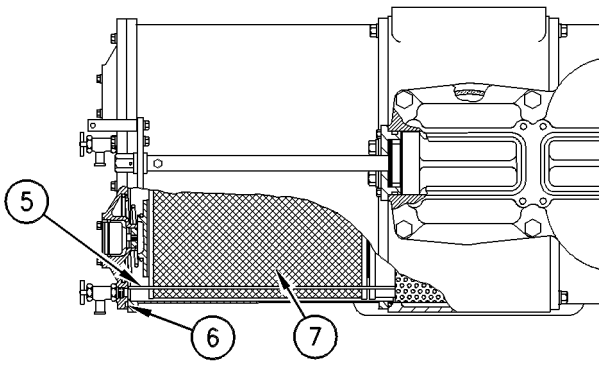


Illustration 101 g00215989

(5) Wire rack
(6) O-ring seal
(7) Element

4. Elements (7) are mounted on wire racks (5) inside the housing. Use a pan to catch the oil that drips when wire racks (5) are removed. Remove wire racks (5). Remove used elements (7). Clean up any oil that is spilled.

NOTICE

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

5. Ensure that the new oil filter elements are in good condition. Place the elements on wire rack (5). Install the wire rack and the elements.

6. Ensure that the surfaces for O-ring seals (6) are clean. Inspect the O-ring seals. If the old O-ring seals are damaged or deteriorated, replace the old O-ring seals with new O-ring seals. Install the O-ring seals.

7. Install covers (3). Ensure that the spring is seated properly between elements (7) and covers (3). Close drain valves (2).

8. Ensure that the crankcase is filled with oil. Operate the prelube pump and rotate the control valve (if equipped) to the “FILL” position for each housing. After both of the housings are full of oil, turn the control valve (if equipped) to the “RUN” position.

9. Start the engine. Check for oil leaks.

Replacing the Engine Oil Filters During Engine Operation

⚠ WARNING

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

If rapid air movement exists to blow fluid, Stop the engine to avoid fire.

If it is necessary to replace the oil filters during engine operation, perform the following procedure.

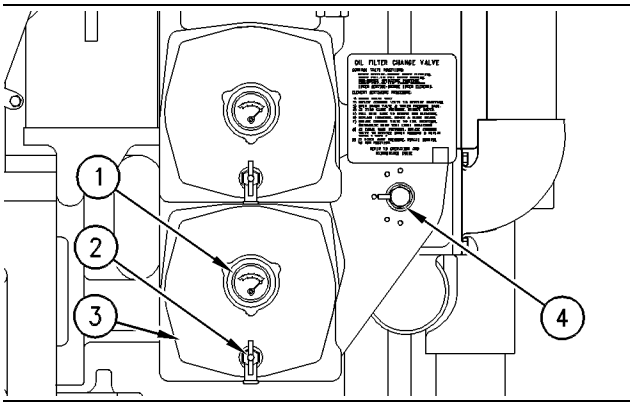


Illustration 102 g00296711

(1) Pressure gauge
(2) Drain
(3) Cover
(4) Control valve

1. Connect a hose from drain valve (2) to a suitable container in order to catch the oil.

2. Rotate control valve (4) to the “LOWER SERVICE” position.

3. Open drain valve (2) and drain the lower oil filter housing. Observe pressure gauge (1) until the pressure is “0”.

Note: Some oil will remain in the housing after the oil has been drained. This oil will pour out of the housing when cover (3) is removed. Prepare to catch the oil in a suitable container. Clean up any spilled oil with rags. DO NOT use absorbent particles to clean up the oil.

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

4. After zero pressure has been reached, remove cover (3). Be alert to the spring force. The cover has a spring force up to 240 N (54 lb). Gradually loosen but do not remove the last two bolts or nuts that are located at opposite ends of cover (3). Before removing the last two bolts or nuts, pry the cover loose or tap the cover with a rubber mallet in order to relieve any spring pressure.

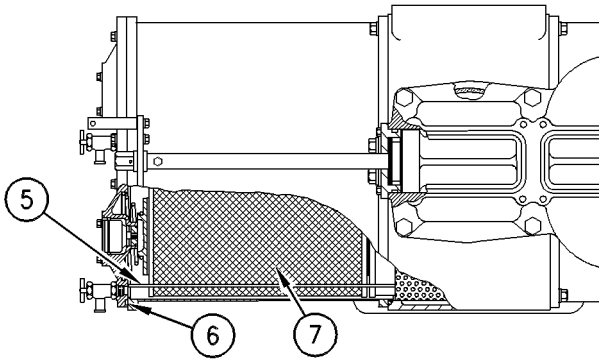


Illustration 103 g00215989

(5) Wire rack
(6) O-ring seal
(7) Element

5. Elements (7) are mounted on wire rack (5) inside the housing. Use a pan to catch the oil that drips when wire rack (5) is removed. Remove wire rack (5). Remove used elements (7). Clean up any oil that is spilled.

NOTICE

Caterpillar oil filters are built to Caterpillar specifications. Use of an oil filter not recommended by Caterpillar could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Caterpillar.

6. Ensure that the new oil filter elements are in good condition. Place the elements on wire rack (5). Install the wire rack and the elements.

7. Ensure that the surfaces for O-ring seal (6) are clean. Inspect the O-ring seal. If the old O-ring seal is damaged or deteriorated, replace the old O-ring seal with a new O-ring seal. Install the O-ring seal.

8. Install cover (3). Ensure that the spring is seated properly between element (8) and cover (3). Close drain valve (2).

9. Rotate control valve (4) to the “LOWER FILL” position. Observe pressure gauge (1). Check cover (3) for leaks.

Note: A hydraulic stop will limit the rotation of the control valve until the oil filter housing is full of oil.

10. After the pressure of the lower oil filter and the upper oil filter is equal, rotate control valve (4) to the “UPPER SERVICE” position. Repeat Step 1 through Step 9 for the upper oil filter.

11. After the oil filters have been serviced and after the pressure of the lower oil filter and the upper oil filter is equal, rotate control valve (4) to the “RUN” position.

Inspect the Used Oil Filter Elements

Cut the used oil filter element open with a utility knife. Remove the metal wrap. Cut the filter element free from the end caps. Spread apart the pleats and inspect the element for metal debris. An excessive amount of debris in the element may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the nonferrous metals that are found in the element. Ferrous metals may indicate wear on the steel and the cast iron parts of the engine. Nonferrous metals may indicate wear on the aluminum parts, the brass parts, or the bronze parts of the engine. Parts that may be affected include the following components: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Aluminum debris may indicate problems with the bearings of the front gears. If aluminum debris is found, inspect the crankshaft vibration damper and the bearings of the front idler gear.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter element. If an excessive amount of debris is found in the oil filter element, consult your Caterpillar dealer in order to arrange for further oil analysis.

i02050563

Engine Oil Level - Check

SMCS Code: 1348-535-FLV

The most accurate check of the oil level is performed when the engine is stopped. Perform this maintenance on a surface that is as level as possible.

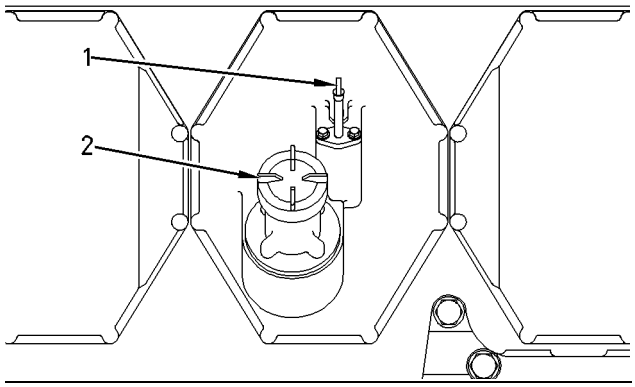


Illustration 104 g00748492

(1) Oil level gauge (dipstick)
(2) Oil filler

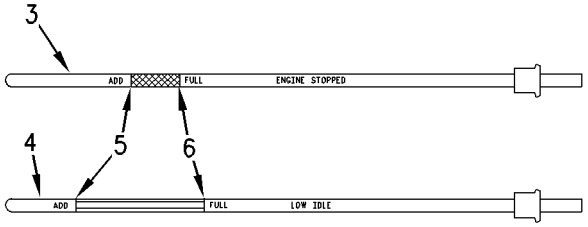


Illustration 105 g00748491

(3) “ENGINE STOPPED WITH OIL COLD” side
(4) “ENGINE AT LOW IDLE WITH WARM OIL” side
(5) “ADD” mark
(6) “FULL” mark

1. Ensure that oil level gauge (1) is seated.

a. If the engine is stopped, remove oil level gauge (1). Observe the oil level on “ENGINE STOPPED WITH OIL COLD” side (3).

b. If the engine is operating, reduce the engine speed to low idle. Remove oil level gauge (1) and observe the oil level on “ENGINE AT LOW IDLE WITH WARM OIL” side (4).

The oil level should be between “ADD” mark (5) and “FULL” mark (6).

NOTICE
Engine damage can occur if the crankcase is filled above the “FULL” mark on the oil level gauge (dipstick).

An overfull crankcase can cause the crankshaft to dip into the oil. This will reduce the power that is developed and also force air bubbles into the oil. These bubbles (foam) can cause the following problems: reduction of the oil’s ability to lubricate, reduction of oil pressure, inadequate cooling, oil blowing out of the crankcase breathers, and excessive oil consumption.

Excessive oil consumption will cause deposits to form on the pistons and in the combustion chamber. Deposits in the combustion chamber lead to the following problems: guttering of the valves, packing of carbon under the piston rings, and wear of the cylinder liner.

If the oil level is above the “FULL” mark on the oil level gauge, drain some of the oil immediately.

2. If necessary, remove oil filler cap (2) and add oil. For the correct oil to use, see this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic (Maintenance Section). Do not fill the crankcase above “FULL” mark (6). Clean the oil filler cap. Install the oil filler cap.

3. Record the amount of oil that is added. For the next oil sample and analysis, include the total amount of oil that has been added since the previous oil change. This will help to provide the most accurate oil analysis.

i00976229

Engine Oil Sample - Obtain

SMCS Code: 1348-554-SM

In addition to a good preventive maintenance program, Caterpillar recommends using S·O·S oil analysis at regularly scheduled intervals in order to monitor the condition of the engine and the maintenance requirements of the engine.

Obtain the Sample and the Analysis

⚠ WARNING

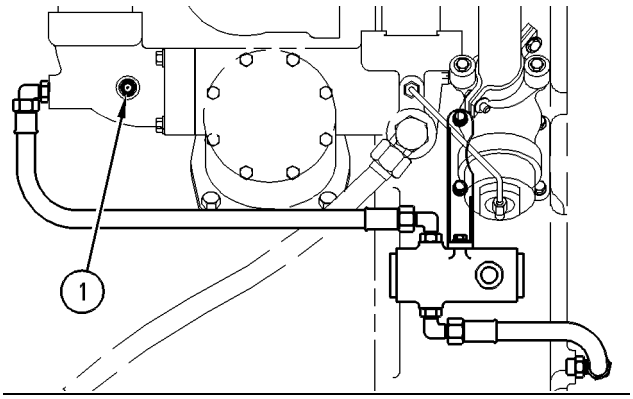
Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Before taking the sample, complete the Label, PEEP5031 for identification of the sample. To help obtain the most accurate analysis, provide the following information:

- Engine model
- Service hours on the engine
- The oil’s hours of use
- The amount of oil that has been added since the last oil change

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.



g00496859

Illustration 106

Particle Sensor

(1) Oil sampling valve

Caterpillar recommends using the sampling valve in order to obtain oil samples. The quality and the consistency of the samples is better when the sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

The 8T-9190 Fluid Sampling Bottle Group is recommended for use with the sampling valve. The bottle group includes the parts that are needed for obtaining oil samples. Instructions are also provided.

NOTICE
Do not use the same vacuum sampling pump for extracting oil samples that is used for extracting coolant samples.

A small residue of either type sample may remain in the pump and may cause a false positive analysis for the sample being taken.

Always use a designated pump for oil sampling and a designated pump for coolant sampling.

Failure to do so may cause a false analysis which could lead to customer and dealer concerns.

If the engine is not equipped with a sampling valve, use the 1U-5718 Vacuum Pump. The pump is designed to accept sampling bottles. Disposable tubing must be attached to the pump for insertion into the sump.

For instructions, see Special Publication, PEHP6001, “How To Take A Good Oil Sample”. Consult your Caterpillar dealer for complete information and assistance in establishing an S·O·S program for your engine.

i00839584

Engine Oil Temperature Regulator - Replace

SMCS Code: 1330-510

The oil temperature regulators divert the engine oil to the oil cooler in order to maintain engine oil temperature.

For instructions on replacing the oil temperature regulators, see the Service Manual, “Disassembly and Assembly” module.

i02354755

Engine Protection Devices - Calibrate

SMCS Code: 7400-524

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints.

To prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests.

- For the calibration of temperature contactors, see Special Instruction, SEHS9827, “Calibration of Temperature Contactors”.
- For the calibration of pressure contactors, see Special Instruction, SEHS9828, “Calibration of Pressure Contactors”.
- For engines with the Caterpillar Marine Monitoring System, see Owner’s Manual, SEBU7134, “Marine Monitoring System”.

Consult your Caterpillar dealer or refer to the Service Manual for more information.

i01428946

Engine Protective Devices - Check

SMCS Code: 7400-535

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. It is impossible to determine if the engine protective devices are in good working order during normal operation. Malfunctions must be simulated in order to test the engine protective devices.

NOTICE
During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

Perform a Static Test

Inspect the components of the alarm and shutoff systems for good condition. Test the operation of the alarms and shutoffs.

A static test of the engine protective devices will ensure that the alarms and shutoffs are functioning properly.

To prevent damage to the engine, only authorized service personnel or your Caterpillar dealer should perform the tests.

Consult your Caterpillar dealer or refer to the Service Manual for more information.

Inspect the Connections of the Engine Protective Devices

Inspect the wiring and the electrical connections for these components:

- Connectors
- Control panel
- Junction box
- Sensors

1. Turn the engine control switch to the "OFF/RESET" position. Open the circuit breaker or circuit breakers of the main power supply.
2. Inspect all of the wiring for the following conditions:
   - Fraying
   - Damaged insulation
   - Corrosion

   Make repairs, as needed.

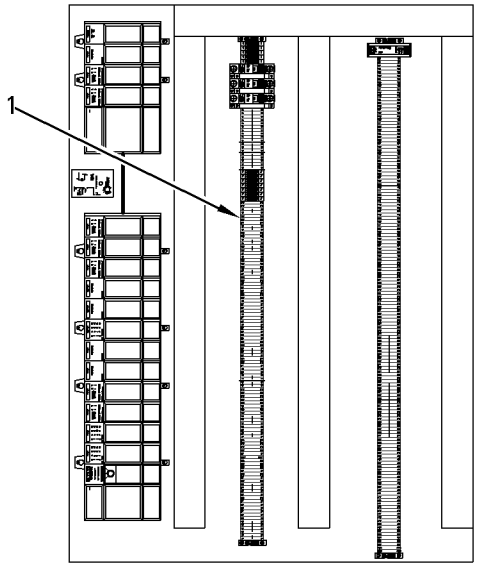


Illustration 107 g00748501

(1) Terminal strips

3. Check the wiring for secure connections at these points of the junction box and the control panel:
   - Connectors
   - Relays
   - Switches
   - Terminal strips

   Perform a pull test for each wire. This test will ensure that the wiring is properly attached. Test each wire individually.

   a. Pull each wire with approximately 45 N (10 lb) of force. Pull the wire firmly.

   If a wire is loose, repair the connection.

4. Inspect the wiring at the relays and terminal strips for these conditions:
   - Corrosion
   - Fraying

   a. If corrosion is found, scrape large deposits. Use cotton swabs with denatured alcohol to clean any corrosion that remains.

   Investigate the source of the corrosion. Correct the condition.

   If damage is found, replace the part.

   b. Remove frayed strands of wire or tin the wire.

   c. Perform Steps 6 and 7 for the connectors of the control panel and the junction box.

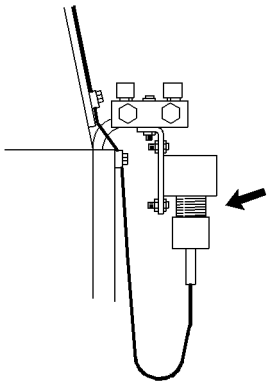


Illustration 108 g00495500

Jaeger connector

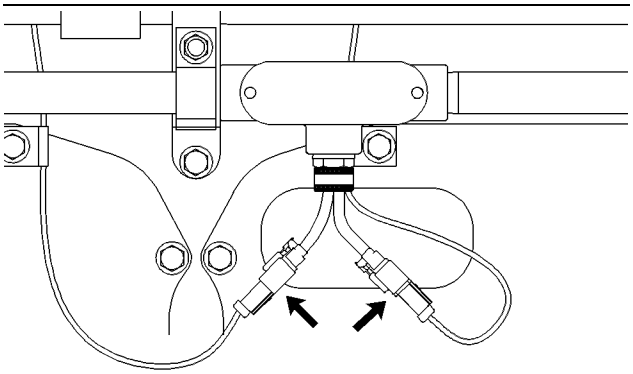


Illustration 109 g00495342

Deutsch DT connectors

Note: The wiring is soldered to the pins and sockets of Military Standard and Jaegerconnectors. The wiring is crimped into the pins and sockets of Deutsch DT connectors.

5. Check the wiring for secure connections at these points:

   - Connectors
   - Sensors

   Perform a pull test for each wire. This test will ensure that the wiring is properly attached. Test each wire individually.

   a. For wiring that is attached to a connector, hold the body of the connector with one hand. Pull each wire with approximately 45 N (10 lb) of force. Pull the wire firmly.

   b. Before testing the wiring of the sensors, ensure that the sensors are securely installed. Then pull each wire with approximately 45 N (10 lb) of force.

      If a wire is loose, repair the connection.

6. Disconnect the connectors at the following locations. Inspect the connectors.

   - Engine sensors
   - Junction box
   - Modules of the control panel

   a. Inspect each pin and each socket for corrosion and damage.

      If corrosion is found, scrape large deposits. Use cotton swabs with denatured alcohol to clean any corrosion that remains. Investigate the source of the corrosion. Correct the condition.

      If damage is found, replace the part.

7. Reconnect the connectors.

   a. For Military Standard and Jaeger connectors, ensure the following conditions:

      - The connection is threaded properly.
      - The connection is threaded completely. Very little thread or no thread is visible.

   b. For Deutsch DT connectors, ensure that the plug and the receptacle are securely connected.

8. Close the circuit breaker or circuit breakers of the main power supply.

i01217276

Engine Timing, Synchronization, and Valve Lash - Inspect/Adjust

SMCS Code: 1102-040; 1105-535; 1290-040

Change the fuel from heavy fuel oil to distillate fuel before performing this procedure. **The use of distillate fuel is necessary for synchronization of the fuel injectors.**

For instructions on the following procedures, see the Service Manual, “Systems Operation/Testing and Adjusting” module. Consult your Caterpillar dealer for assistance.

Check the Timing of the Crankshaft and Camshaft

The timing of the crankshaft and camshaft must be checked, and the valve bridge must be adjusted before the valve lash is adjusted. The camshafts must be correctly timed with the crankshaft before the fuel timing is adjusted.

NOTICE

The timing pins must be removed from the camshafts before the crankshaft is rotated or damage to the cylinder block will result.

NOTICE
DO NOT use the starting motor to rotate the crankshaft. The lubrication oil can drain out from between the crankshaft and the engine bearings if the engine has not been operated for a period of time. Damage can result if the crankshaft is rotated on dry bearing surfaces.

To prevent damage to the crankshaft bearings, DO NOT crank the engine before prelube, especially after this maintenance procedure.

NOTICE
The prelube pump should not be operated continuously for extended periods of time. If, during repairs, the prelube pump has run continuously for a period of three hours or more, it will be necessary to remove any oil that may have collected in the cylinders and/or above the valves.

Prelube of the engine is required before the crankshaft is rotated for normal maintenance. Activate the prelube pump for rotating the engine crankshaft.

NOTICE
Do not use an impact wrench to operate the barring device. The use of an impact wrench will cause gear tooth failure.

The barring device provides a means for slowly turning the flywheel in order to service the engine. The barring device can also be used to prevent rotation of the crankshaft. Refer to the Service Manual for information on operation of the barring device.

Fuel Injector Timing (Fuel Timing)

The camshafts must be correctly timed with the crankshaft before the fuel timing is adjusted. The fuel timing dimension is stamped on the engine Information Plate.

Fuel Injector Clamp

The top surface of the clamp for the fuel injector must be parallel to the top surface of the cylinder head. The specification for the clearance is described in the Service Manual, “Specifications” module.

Fuel Injector Synchronization

Synchronize the fuel injectors. When this maintenance procedure is complete, ensure that the barring device is disengaged from the flywheel and ensure that the handle of the barring device is secured in the disengaged position.

Valve Bridge

NOTICE
Do NOT attempt to adjust the valves if the crankshaft and camshaft are not synchronized. Disregard for this can result in engine damage such as bent valves.

Check the valve bridge and adjust the valve bridge, if necessary. Perform the procedure for both valve bridges for each cylinder. If the valve bridges for the inlet valves require frequent adjustment, the lubricator for the inlet valve may not be operating. The lubricator may not be adjusted properly.

After the valve bridge is checked for each cylinder, proceed with the valve lash adjustment, if necessary.

Engine Valve Lash

Note: The specification for the valve lash is listed in this Operation and Maintenance Manual, “Engine Description” topic (Product Information Section).

If the valve lash is within the tolerance, an adjustment of the valve lash is NOT necessary.

The crankshaft and camshaft timing must be checked, and valve bridge adjustment must be performed before making a valve lash adjustment.

Perform the valve lash setting when the engine is cold. After the engine has been shut down and the valve covers are removed, the engine is considered cold.

Before performing maintenance, prevent the entry of foreign matter into the top of the cylinder head and the valve mechanism. Thoroughly clean the area around the valve mechanism covers.

i01765711

Engine Valve Rotators - Inspect

SMCS Code: 1109-040

NOTICE
A valve rotator which does not operate properly will accelerate valve face wear and valve seat wear and shorten valve life. If a damaged rotator is not replaced, valve face guttering could result and cause pieces of the valve to fall into the cylinder. This can cause piston and cylinder head damage.

Note: Use of a platform may be necessary to reach the engine valve rotators.

Perform this procedure after the valve lash has been set.

1. Mark the tops of the valve rotators with a permanent marker. Note the position of the marks.
2. Install the valve covers. See the Service Manual for the procedure.
3. Start the engine. Operate the engine for 5 minutes. Stop the engine.
4. Remove the valve covers. Observe the position of the marks that are on the valve rotators.

If a valve fails to rotate, consult your Caterpillar dealer.

i00957883

Exhaust Manifold - Inspect

SMCS Code: 1059-040

Inspect the exhaust manifold for buildup of deposits. A thin layer of buildup can increase the operating temperature of the engine.

To inspect the exhaust manifold, gain access to the manifold according to the instructions in the Service Manual, “Disassembly and Assembly” module.

Use the following procedure to clean the exhaust manifold, if necessary:

1. Remove the exhaust manifold according to the instructions in the Service Manual, “Disassembly and Assembly” module.
2. Soak the exhaust manifold in water.
3. Use a steel scraper to remove most of the deposits. Remove the remainder of the deposits with a steel brush. Remove any remaining debris with a nylon brush.
4. Install the exhaust manifold according to the instructions in the Service Manual, “Disassembly and Assembly” module.

i01003546

Exhaust Piping - Inspect

SMCS Code: 1061-040

⚠ WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

Inspect the components of the exhaust system. Repair the components or replace the components for any of the following conditions:

- Damage
- Cracks
- Leaks
- Loose connections

For information on removal and installation, see the Service Manual, “Disassembly and Assembly” module. Consult your Caterpillar dealer for assistance.

i00457458

Exhaust Shields - Inspect

SMCS Code: 1067-040

⚠ WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

NOTICE
The exhaust shields can be damaged if work is performed on the exhaust shields or around the exhaust shields.

Remove the exhaust shields or protect the exhaust shields before performing work on the exhaust shields or around the exhaust shields. Handle the exhaust shields carefully.

Do not tear the foil that is inside of the exhaust shields. Torn foil will allow the insulation to absorb flammable liquids and a fire can result from engine heat.

Ensure that the exhaust manifold is cool. Inspect the exhaust shields. Replace any exhaust shield that is damaged. Refer to the Service Manual for the procedure to remove the exhaust shields and install the exhaust shields.

i01216672

Fuel - Changeover

SMCS Code: 1280

Caterpillar 3600 Series Heavy Fuel Engines are designed to use heavy fuels for starting, operating, and stopping. These engines can also operate on distillate fuel. Also, these engines may be operated on distillate fuel when the supply of heavy fuel is restricted, reduced, or eliminated. During the changeover between fuels, these engines can use a mixture of distillate fuel and heavy fuel oil.

Use caution not to change between heavy fuel and distillate fuel too quickly. Differences in the control of the fuel temperature can cause thermal shock and a lack of lubricity to the unit injectors.

The following recommendations are based on having a system that meets Caterpillar recommendations and industry standards. The design of the system includes these features:

- A three-way valve for the selection of heavy fuel or distillate fuel
- A separate isolated distillate fuel supply for the engine and/or engines

Circumstances for Changing the Fuel

Caterpillar 3600 Series Heavy Fuel Engines are designed to use heavy fuels for normal operation. However, it is preferable to operate with distillate fuel before stopping the engine for the following circumstances:

- Performance of service on fuel system components such as fuel filters and unit injectors
- The engine is shut down for an undetermined period of time without circulation of the fuel through the engine.

The following definitions will assist operators in determining the circumstances for changing the fuel:

General recommendation – Flush the engine fuel system with distillate fuel prior to performing any maintenance on the fuel system. Flush the fuel system with distillate fuel if the engine is shut down for more than 12 hours. If the jacket water heaters are not functional, flush the fuel system with distillate fuel after every engine shut down.

Temporary shutdown – The engine is shut down for 12 hours or less. It is not necessary to change the fuel. The engine can be stopped and started with heavy fuel. Jacket water heaters must be operated in order to maintain the temperature of the jacket water at a minimum of 65 °C (149 °F). Continue to circulate heavy fuel through the engine in order to maintain the temperatures of fuel system components for start-up. The fuel must have the correct viscosity and temperature at all times.

Extended shutdown – The engine is shut down for more than 12 hours or for an unknown length of time. Flush the engine fuel system with distillate fuel. Unless cold ambient conditions make the use of jacket water heaters necessary, use of jacket water heaters is not required. Shut off the circulation through the fuel system and the module for cooling the unit injector tips. Purge the pressurized air from the air lines and from the starting motor. Lock the air valves to the starting motor in the OFF position. Space heaters for the generator must be operational.

Recommendations for Shutdown and Start-up

The use of proper operating practices is important. The following guidelines are recommended:

- For generator sets, operate the space heaters when the generator is not operating. This will help to prevent moisture damage to windings. The space heaters can be controlled with a thermostat or a relay.

- A lack of proper temperature control can lead to problems with the unit injectors or other fuel system components. Operate the jacket water heaters when the engine is shut down. This will help to maintain proper temperatures for start-up in the cylinder heads, cylinder liners, and fuel system components. Maintain the jacket water temperature to a minimum of 65 °C (149 °F).

- Follow the recommended procedures before starting any engine. Incomplete procedures can lead to system malfunctions that do not allow engine operation. See this Operation and Maintenance Manual, “Engine Starting” topic (Operation Section).

- Prior to starting any engine after an overhaul or after servicing the fuel system, ensure that all of the engine protective devices will function. Prepare to use the emergency stop button, if necessary.

- Test the engine with distillate fuel after an overhaul or after servicing the fuel system. Perform the test before changing to heavy fuel. If an unexpected problem occurs, distillate fuel is easier to clean up. For example, if a leak develops after starting, cleaning up heavy fuel oil would be more difficult than cleaning up distillate fuel.

Fuel Bypass Valve

During normal operation, the valves for the fuel supply lines and the fuel return lines are open. The bypass valve between the supply lines and return lines is closed. When the fuel supply lines and the fuel return lines are closed, fuel does not flow to the fuel filters. The filters will cool. Hours may be required for heating the fuel filters before starting the engine. When the fuel to an engine is changed, the bypass valve must be adjusted in order to maintain the correct fuel system pressure. Adjustment of the bypass valve also maintains the circulation of fuel through the fuel system when the fuel supply and return lines are closed.

For sites with more than one engine sharing one fuel oil conditioning module, the fuel pressure to any operating engine will increase when another engine is shut down. When the fuel to an engine is changed, the bypass valve must be adjusted in order to maintain the correct fuel system pressure to any operating engine. Normal supply pressure from the fuel oil conditioning module is 6.5 to 7 bars. This pressure is needed in order to maintain a pressure of 550 to 620 kPa (80 to 90 psi) to any operating engine.

Changing the Fuel

The method that is used for changing the fuel depends on the equipment that is used. Different sites may have different equipment. The following methods are possible:

- The fuel system can be flushed through the use of auxiliary fuel pump, a separate fuel tank, and fuel lines.

- The fuel supply can be switched through the use of a dual source of fuel at the fuel oil conditioning module.

A motorized three-way valve with a clock timer is recommended for changing the fuel. This valve can be used with a single engine and with sites that have more than one engine sharing one fuel oil conditioning module. The fuel can be changed during engine operation or after stopping.

Changeover From Heavy Fuel Oil To Distillate Fuel During Engine Operation

NOTICE
The preheat temperature for pure distillate fuel must not exceed 60 °C (140 °F). At temperatures above 60 °C (140 °F), distillate fuel loses the lubricating properties. Operating an engine on fuel with insufficient lubricity can damage the unit injectors.

NOTICE
To prevent excessive injection pressures when the fuel is changed to heavy fuel oil, the engine must not be operated at more than 75 percent of rated load.

1. Operate the engine at reduced load.

2. Set the timer for the three-way valve to 45 to 50 minutes.

3. Make sure that all of the valves from the distillate fuel line to the fuel booster module are OPEN.

4. Change the fuel selector switch on the control box for the fuel booster module from heavy fuel oil to distillate fuel.

5. Monitor fuel temperature and fuel viscosity during the changeover. Adjust the bypass valve in the fuel lines in order to balance the fuel supply pressure to each engine at 550 to 620 kPa (80 to 90 psi).

6. When the fuel viscosity is reduced to ten cSt, slowly open the valve which allows fuel flow through the fuel cooler until there is a maximum flow of fuel to the fuel cooler.

7. When the fuel viscosity reaches eight cSt, slowly close the supply of steam to the Vokes filter.

8. When the full fuel flow is directed through the fuel cooler, the fuel viscosity will continue to decrease to a final level of four to five cSt. After four to five cSt is reached, operate the engine at constant load for 15 minutes. This step will ensure that all of the heavy fuel has been cleared from the engine prior to reducing the load or increasing the load.

9. If you are reducing the load in order to stop the engine, remove the load and allow an appropriate cooldown period before you shut down the engine.

10. After the engine has stopped, close the fuel supply and fuel return lines at the engine. Close the supply lines and the return lines for injector tip cooling.

Changeover from Distillate Fuel to Heavy Fuel Oil During Engine Operation

NOTICE
To prevent excessive injection pressures when the fuel is changed to heavy fuel oil, the engine must not be operated at more than 75 percent of rated load.

Note: The complete procedure for changing the fuel may require an hour of time. This depends on the load conditions and the volume of fuel in the system.

1. Operate the engine and/or engines at a reduced load. Move the selector switch for fuel on the fuel booster module from distillate fuel to heavy fuel oil.

2. Monitor fuel temperature and viscosity during the changeover to heavy fuel. Maintain the fuel supply pressure to each engine at 550 to 620 kPa (80 to 90 psi).

   If necessary, adjust the fuel bypass valve. Be careful to avoid sudden changes in either fuel temperature or fuel viscosity during the changeover. Check the routing of the fuel valve. Route sufficient fuel through the fuel cooler before the fuel is returned to the fuel booster module. Make sure that the fuel viscosity stabilizes at approximately 15 to 20 cSt at the unit injectors.

3. After the changeover is complete and the fuel temperature and viscosity are stable, shut off the distillate fuel supply to the fuel booster module.

Changeover from Heavy Fuel Oil to Distillate Fuel After Engine Shutdown

This procedure is based on the following conditions:

- The engine was stopped during operation with heavy fuel oil.
- The jacket water heater is operating.

1. Adjust the engine's fuel supply line from heavy fuel oil to distillate fuel.

   The clean distillate fuel will become contaminated with heavy fuel oil while the engine's fuel system is being flushed. Adjust the fuel return line in order to return the fuel to the day tank for heavy fuel oil.

2. Adjust the fuel bypass valve in order to maintain fuel pressure of 550 to 620 kPa (80 to 90 psi) to any engine and/or engines that are operating.

3. Start the pump for the distillate fuel supply to the engine that is being flushed. Monitor the fuel pressure to the engine.

4. Monitor the fuel that is returned to the day tank for heavy fuel oil. When the fuel that is returning to the tank is not contaminated with heavy fuel oil, switch the fuel return line to the day tank for distillate fuel.

5. Stop the pump for the distillate fuel supply.

6. Close the valves for the fuel supply and the fuel return at the engine. Make sure that the valves for the coolant supply and the coolant return for the injector tips are closed.

   Proceed with the maintenance.

i00937115

Fuel Analysis - Obtain

SMCS Code: 1280-554

The composition of fuel varies between different sources. Also, the composition of the fuel within a single delivery can vary. For these reasons, frequent sampling of the fuel is required throughout the engine's fuel system.

The frequency of sampling and the locations for obtaining the samples will vary because of these factors: on-site conditions, quality of the fuel, engine performance, and the performance of the system that processes the fuel.

Sample the fuel according to the recommendations in Special Instruction, REHS0104, "Guidelines for 3600 Heavy Fuel Oil (HFO) Engines".

i00938862

Fuel Oil Conditioning Module - Check

SMCS Code: 1280-535; 1901-535

Operate the fuel conditioning module (fuel booster module group) on viscosity control during all normal operations. This automatic sensing and control will account for slight variations in the supply of fuel. These variations in the fuel even occur within a single shipment of fuel. Properly adjust the viscosity control in order to account for losses of heat in the engine piping as fuel is delivered. The viscosity of the fuel at the engine must be between 10 cSt and 20 cSt. The temperature of the fuel at the engine must not exceed 135 °C (275 °F).

When the supply of fuel is changed, monitor the viscometer during the changeover in order to ensure that the viscosity control is responding correctly.

Correct fuel temperature is important at the engine. The fuel must be sufficiently preheated before the injectors, or the following conditions will result:

- Extremely high pressures in the injection system
- An increase of the mechanical load on many components
- An increase of the thermal load
- Poor atomization of the fuel in the cylinder which leads to incomplete combustion
- Fouling of the combustion chamber
- Fouling of the exhaust system

Excessive preheat temperatures can also cause problems. Excessive preheat temperatures may cause a thermal breakdown of the fuel, especially if the fuel contains large amounts of cracked constituents. This thermal breakdown may lead to plugging of the system that is used to treat the fuel. Deposits may also form in the system.

The fuel system components must be carefully operated and maintained continuously. The delivery of clean fuel at the proper viscosity is essential to reliable engine performance. Frequently sample and analyze the fuel for cleanliness at the engine. Carefully document these samples in case future questions arise regarding quality of the fuel or operation of the engine. Immediately resolve any problems, if a discrepancy is detected.

The engine operator must remember that there are no alarms for fuel quality. Only the proper operation and maintenance of the entire system leads to successful operation of heavy fuel engines. The proper operation also includes the sampling and analysis of fuel oil.

Daily

Note: When the fuel supply is changed, monitor the viscosity in order to ensure that the viscosity control is operating properly.

Perform the maintenance that is recommended by the OEM of the module.

- Check the operation of the deaerator system. This system removes air from the fuel. Air that is mixed with the fuel will cause the engine to run rough. In some cases, the engine will stall. Vent any air that is entrained in the fuel.
- Check the operation of the viscosity control. Ensure that the fuel is provided to the engine at 10 to 20 cSt. Verify the temperature of the steam jacket. Ensure that the temperature of the fuel to the engine does not exceed 135 °C (275 °F).
- Observe the inlet pressure and the outlet pressure of the automatic backflush filter. Record the data.
- Slightly open all of the lines to the transducer in order to verify the presence of a flow of heavy fuel oil.

Every Week

Verify the operation of the selector valve for the duplex filters.

Every 1000 Service Hours

1. Remove the duplex filter elements.
2. Clean the inside of the filter housings.
3. Clean the filter elements.
4. Inspect the filter elements for good condition. Replace the filter elements, if necessary.
5. Assemble the duplex filters.

Every 1500 Service Hours

If the duplex filter elements were not replaced during the 1000 service hour interval, install new filter elements.

Every 3000 Service Hours

Install new duplex filter elements.

i00939024

Fuel Oil Separator - Check

SMCS Code: 1280-535

Note: A separator may also be known as a centrifuge.

The separator separates water and contaminants from the fuel oil. The densities of heavy fuel and water are almost equal. Therefore, the difference in density that is needed for efficient separation is very small. For optimum efficiency, the separator must be operated and maintained according to the recommendations of the OEM of the separator.

The correct supply of heat is critical to proper operation of the separator. Small variations in the temperature of the fuel oil to the separator may cause a large change in the density of the fuel oil. It is very important to keep the fuel temperature constant. Regulate the inlet temperature to the separator to a tolerance of ± 2 °C.

The temperature of the fuel to the separator depends on the viscosity of the fuel. The heater before the separator must operate at the correct temperature for the viscosity of the fuel. However, the maximum temperature of the fuel from the heater to the separator is 98 °C.

Operate the separator according to the instructions that are provided by the OEM of the separator.

- Check the module according to the instructions that are provided by the OEM of the module. See the engine's Technical Manual.
- Perform the maintenance and service activities that are described in the literature.
- Respond to any alarm immediately. Determine the cause of the alarm and make corrections as soon as possible.

i01216970

Fuel System Fuel Injector - Clean/Inspect

SMCS Code: 1290-040; 1290-070

For instructions on the following topics, see the Service Manual, "Disassembly and Assembly" module:

- Removal and installation of the fuel injectors
- Cleaning the bores for the fuel injectors

1. Remove the fuel injectors from the cylinder head.
2. Perform the following procedures according to Special Instruction, SEHS9741, "Cleaning 3600 Unit Injectors":
   - Cleaning
   - Disassembly
   - Inspection
   - Assembly

   Obtain new fuel injectors, if necessary.
3. Clean the bores for the fuel injectors.
4. Install the fuel injectors.

i01216981

Fuel System Fuel Injector Tip Cooling Module - Check

SMCS Code: 1290-535

Cooling the fuel injector tips provides the following benefits:

- Control of erosion
- Prevention of deposit formation

Check the coolant level. Ensure that a sufficient amount of coolant is in the cooling module.

Inspect the components, the piping, and the connections for leaks. Make repairs, if necessary.

Monitor the temperature and pressure of the system. Record the gauge readings on an hourly basis. Compare the new data to the recorded data.

Check the differential pressure for the filter. Replace the filter element, if necessary.

Check the module according to the instructions that are provided by the OEM of the module. See the engine's Technical Manual. Perform the maintenance and service activities that are described in the literature.

i00938031

Fuel System Primary Filter/Water Separator - Drain

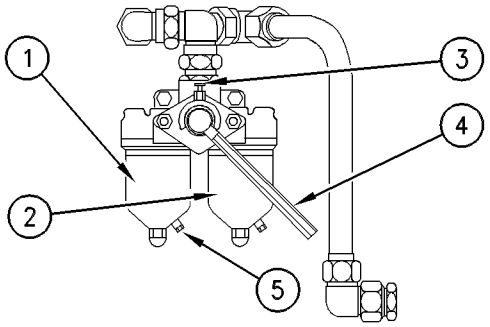
SMCS Code: 1260-543; 1263-543

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

Primary Filter



g00477706

Illustration 110

(1) Filter
(2) Filter
(3) Lock
(4) Lever
(5) Drain valve

1. To drain filter (1), lift lock (3) and turn lever (4) to the “FILTER 2 RUN” position. Release the lock.
2. Hold a suitable container under drain valve (5). Open the drain valve. Allow the moisture to drain. Close the drain valve.
3. Lift lock (3) and move lever (4) to the “BOTH RUN” position for one minute.
4. To drain filter (2), lift lock (3) and turn lever (4) to the “FILTER 1 RUN” position. Release the lock.
5. Repeat Steps 2 and 3 for filter (2).

Water Separator

For specific instructions on draining the water separator, see the service information that is provided by the OEM of the water separator.

NOTICE
The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

i02046822

Fuel System Primary Filter (Water Separator) Element - Replace

SMCS Code: 1260-510-FQ; 1263-510-FQ

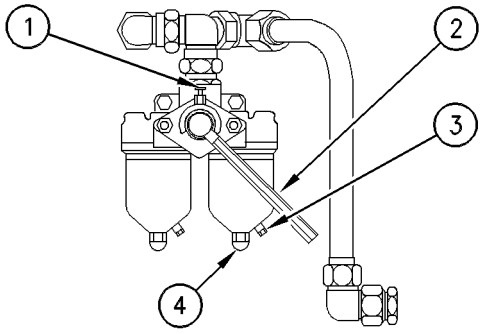
⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

Primary Filter

Servicing the Primary Filters During Engine Operation



g00477786

Illustration 111

Primary filters in the “FILTER 1 RUN” position

(1) Lock
(2) Lever
(3) Drain valve
(4) Nut

1. To service “FILTER 2”, lift lock (1) and turn lever (2) to the “FILTER 1 RUN” position. Release the lock.

2. Hold a suitable container under drain valve (3). Open the drain valve. Allow the moisture to drain. Close the drain valve.

3. Remove nut (4). Remove the filter case.

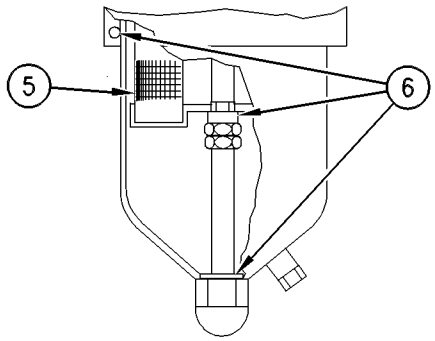


Illustration 112 g00477788

(5) Element
(6) Seals

4. Remove element (5) and seals (6).

5. Clean the filter case, the element, and the seals with clean, nonflammable solvent. Allow the parts to dry.

6. Inspect the element and the seals for good condition. Obtain new parts, if necessary. See the Parts Manual for the engine.

7. Assemble the clean, dry element, seals, and filter case. Use clean diesel fuel on the seals to make installation easier. Tighten nut (4). Close drain valve (3).

8. Lift lock (1) and move lever (2) to the “BOTH RUN” position for one minute.

9. To service “FILTER 1”, lift lock (1) and turn lever (2) to the “FILTER 2 RUN” position. Release the lock.

10. Repeat Steps 2 through 8 for “FILTER 1”.

Servicing the Primary Filters With the Engine Stopped

1. Ensure that the fuel to the engine is OFF.

2. Refer to “Servicing the Primary Filters During Engine Operation”. Perform Steps 2 through 7 for both filters.

It may be necessary to prime the fuel system before the engine will start. See this Operation and Maintenance Manual, “Fuel System - Prime” topic (Maintenance Section).

Water Separator

Replace the water separator element according to the instructions that are provided by the OEM of the water separator.

i00938540

Fuel System Secondary Filter - Replace

SMCS Code: 1261-510-SE

Replace the secondary fuel filter elements when either of the following conditions occurs:

- The fuel filter differential pressure reaches 105 kPa (15 psi).
- The elements have been used for a maximum of 1500 hours of operation.

Operation of the Vokes Fuel Filter

The filter may be operated with the fuel flow through one side of the filter or through both sides of the filter. Either practice is acceptable, provided that the maximum fuel filter differential pressure is not exceeded. Operating with the fuel flow through one side of the filter is recommended.

Operating With One Side of the Filter

Caterpillar recommends operating with the fuel flow through one side of the filter during normal operation. This practice enables the filter elements to be replaced without shutting down the engine. When the maximum fuel filter differential pressure is reached, redirect the fuel flow through the new filter element. The dirty element may then be replaced during operation. The new replacement element is ready for use when the next element is replaced.

Operating With Both Sides of the Filter

When both sides of the filter are active, each element filters 50 percent of the fuel flow. This increases the time between replacement of the elements. However, this practice may require the engine to be shut down in order to replace the elements. This may be suitable for intermittent operation, but not for continuous operation.

During operation, the fuel flow must be directed through one side of the filter in order to replace an element. To avoid exceeding the maximum fuel filter differential pressure during operation, the element must be replaced before the element has reached the maximum pressure. To achieve optimum use of the filter elements, direct the fuel flow through one side of the filter.

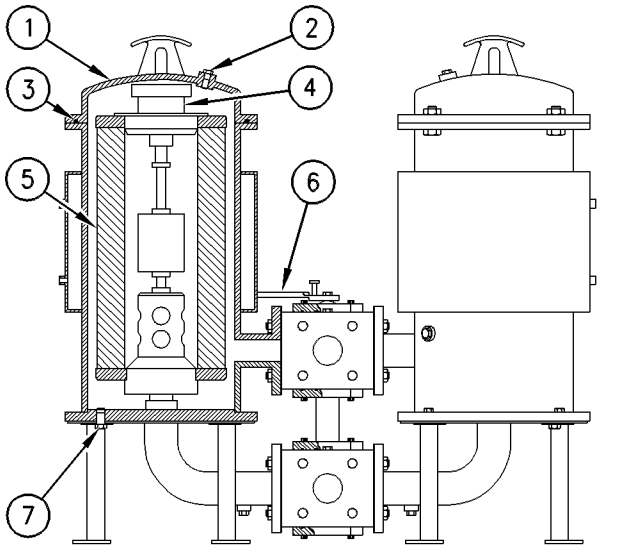
Replacing the Filter Element During Engine Operation

⚠ WARNING

Filter contains hot pressurized fluid when engine is running.

Follow instructions on control valve to avoid personal injury.

If rapid air movement exists to blow fluid, Stop the engine to avoid fire.



g00478070

Illustration 113

(1) Cover
(2) Vent plug
(3) Seal
(4) Retainer
(5) Element
(6) Lever
(7) Drain plug

1. Move lever (6) in order to direct the fuel flow away from the side of the filter that will be serviced.

2. Shut off the heat to the side of the filter that will be serviced.

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over disconnected fuel system component.

3. Loosen vent plug (2). Do not remove the plug.

NOTICE
Use a suitable container to catch any fuel that might spill. Clean up any spilled fuel immediately.

NOTICE
To prevent contamination of the new filter element, ensure that the filter housing is completely drained.

4. Remove drain plug (7). Drain the fuel into a suitable container.

5. Remove cover (1). Be careful not to damage seal (3).

6. Remove retainer (4) and element (5). Discard the used element.

7. Clean the following items with clean, nonflammable solvent:

   - Inside of the filter housing
   - Components inside the filter housing
   - Retainer
   - Cover
   - Seal
   - Drain plug

   Wipe the items dry with a clean cloth. Ensure that the surfaces for the seal are clean.

8. Install a new filter element. Secure the element with retainer (4). Install drain plug (7).

9. Inspect seal (3) for good condition.

   Obtain a new seal, if necessary. See the Parts Manual for the engine.

10. Install seal (3) in cover (1). To make installation easier, coat the seal with clean diesel fuel. Install the cover.

11. Turn on the heat to the side of the filter that has been serviced.

12. Turn handle (6) in order to fill the housing of the new element. Observe the area around vent plug (2) for fuel flow. When fuel flows free of air bubbles, tighten the vent plug. Clean up any fuel that has spilled.

Replacing the Filter Elements With the Engine Stopped

1. Ensure that the fuel to the filter is OFF.

2. Refer to “Replacing the Filter Element During Engine Operation”. Perform Steps 3 through 12 for both sides of the fuel filter.

i00939327

Fuel Tank Water and Sediment - Drain

SMCS Code: 1273-543-M&S

Day Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system. Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the day tank. This causes water to accumulate in the day tank. Draining the day tank regularly and obtaining fuel from reliable sources can help to eliminate water from the fuel.

Day tanks should have a provision for draining water and sediment.

Open the drain valve on the bottom of the day tank in order to drain the water and the sediment. Close the drain valve.

Drain the water and sediment from the day tank daily. The quality of the fuel and/or the operating conditions may require more frequent draining of the water and sediment.

Fill the day tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some day tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some day tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Settling Tank

Drain the water and the sediment from the settling tank daily. Ensure that the temperature of the settling tank is proper for the viscosity of the fuel oil.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank daily. Ensure that the water and sediment is drained from the fuel storage tank when the tank is refilled. This will help prevent water and/or sediment from being pumped from the fuel storage tank into the settling tank.

i00455138

Governor Actuator Linkage - Check

SMCS Code: 1265-535

Check the governor actuator linkage for proper operation. Refer to the Service Manual for the procedure to adjust the governor actuator linkage.

Lubricate the Fuel Control Linkage

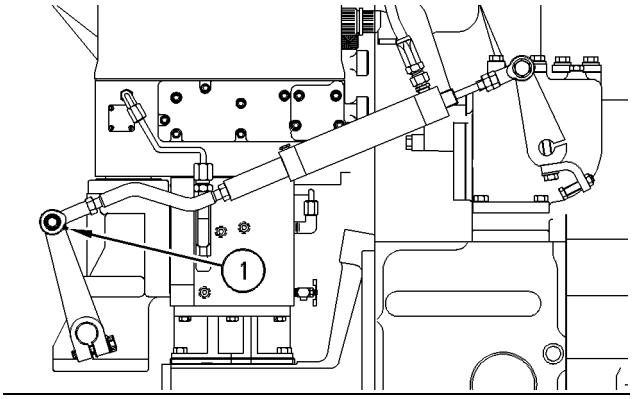


Illustration 114 g00274295

(1) Grease fitting.

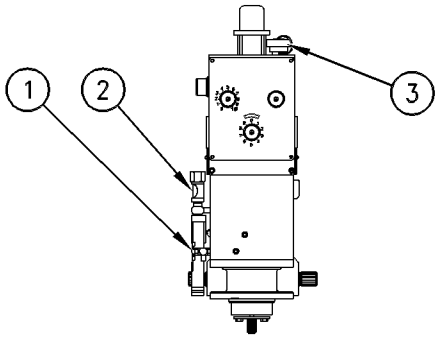
Some governor actuator linkages have grease fittings (1). Lubricate the moving parts of the governor actuator linkage with MPG or equivalent grease.

i02345076

Governor Actuator Oil - Replace

SMCS Code: 1264-510-OC; 1264-510

NOTICE
Contamination of oil is a major cause of problems for governor actuators. Only use new oil. A container that is used to fill the governor actuator must be clean. Rinse the container with the new oil before filling the container.



g00274299

Illustration 115

(1) Drain cock
(2) Sight gauge
(3) Filler cap

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Refer to Special Publication, NENG2500, “Caterpillar Dealer Service Tool Catalog” for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Attach one end of a hose to drain cock (1). Insert the other end of the hose into a suitable container. Open filler cap (3). Open drain cock (1). Allow the oil to drain.

2. Close drain cock (1). Pour clean engine oil into the oil filler until the oil flows out of the vent hole in sight gauge (2). Approximately 1.4 L (1.50 qt) of oil will be required. Clean filler cap (3). Install the filler cap.

3. Check the oil level in sight gauge (2) immediately after the engine is started. Add more oil or drain oil until the oil level is at the center of the sight gauge. Remove the hose from drain cock (1). Clean up any oil that has spilled.

Check the Operation of the Governor Actuator

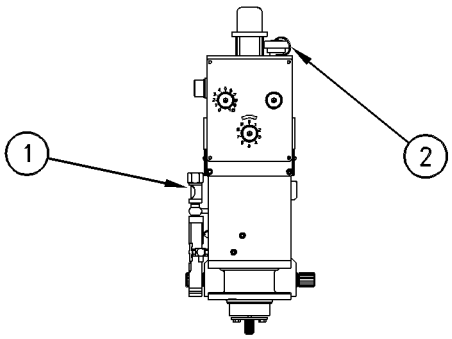
After the oil has been replaced, check the governor actuator for proper operation. Refer to the instructions that are provided by the OEM of the governor actuator or refer to the Service Manual. Consult your Caterpillar dealer for assistance.

i01069930

Governor Actuator Oil Level - Check

SMCS Code: 1264-535-OC; 1264-535

NOTICE
Contamination of oil is a major cause of problems for governor actuators. Only use new oil. A container that is used to fill the governor actuator must be clean. Rinse the container with the new oil before filling the container.



g00274303

Illustration 116

(1) Sight gauge
(2) Filler cap

Observe the oil level in sight gauge (1). If the oil level is below the center of the sight gauge, add oil. Remove filler cap (2). Pour engine oil into the oil filler until the oil level is at the center of the sight gauge. Clean the filler cap. Install the filler cap. Clean up any oil that has spilled.

i01048507

Instrument Panel - Inspect

SMCS Code: 7451-040

Inspect the instrument panel for good condition. Perform the self-test. All of the warning lamps should illuminate. If a warning lamp does not illuminate, replace the bulb immediately. If the alarm does not sound, investigate the problem and correct the problem.

Check the condition of all of the gauges. If a gauge is broken, repair the gauge or replace the gauge immediately.

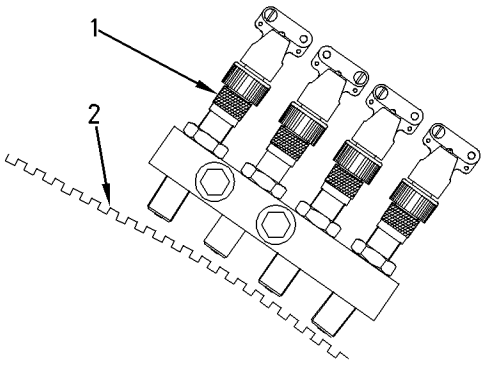
Frequently monitor the gauges during normal operation.

Record the data in a log. Compare the new data to the data that was previously recorded. Comparing the new data to the recorded data will help to establish the trends of engine performance. A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

i01428855

Magnetic Pickups - Clean/Inspect

SMCS Code: 1907-040



g00748456

Illustration 117

(1) Magnetic pickup
(2) Flywheel ring gear

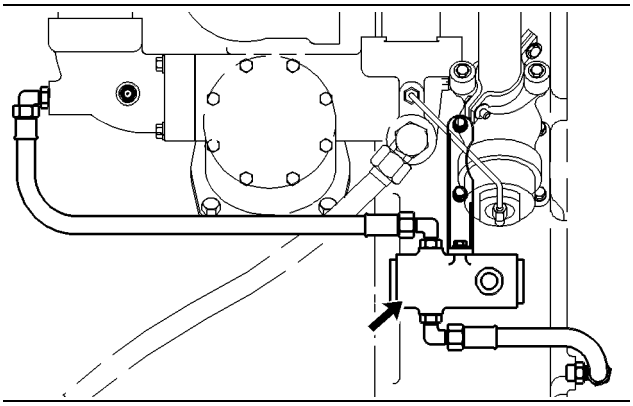
1. Remove the magnetic pickup from the flywheel housing.
2. Clean the face of the magnet. Check the condition of the magnetic pickup.
3. Install the magnetic pickup in the flywheel housing. Turn the magnetic pickup clockwise until the magnet contacts a tooth of the flywheel ring gear.
4. Turn the magnetic pickup counterclockwise for 1 1/4 turns (450 ± 30 degrees). Maintain a clearance of 0.70 ± 0.15 mm (.028 ± .006 inch) between the magnetic pickup and the tooth of the flywheel ring gear. Tighten the locknut to 47 ± 7 N·m (35 ± 5 lb ft).

i02343231

Metal Particle Detector - Inspect

SMCS Code: 7400-040

If the metal particle detector causes a shutdown, inspect the detector.



g00546054

Illustration 118

Metal particle detector

1. Remove the grid from the inside of the detector.
2. If metal particles are found, determine the source of the particles.

NOTICE

Metal particles in the lube oil may indicate a serious condition that requires immediate attention.

If metal particles are found in the grid of the detector, do not start the engine until the source of the particles is found and the condition is corrected. Failure to do so could cause severe damage to the engine.

3. Clean the grid with nonflammable solvent. Install the clean, dry grid.

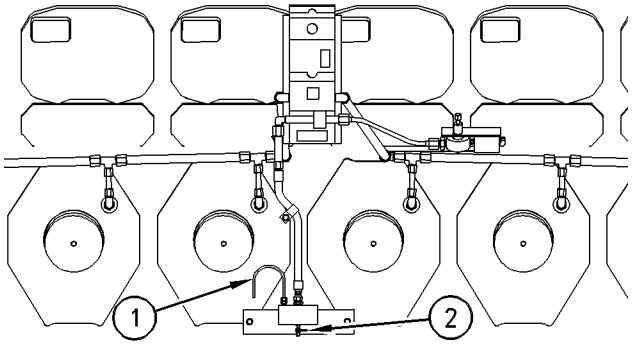
i01979490

Oil Mist Detector - Check

SMCS Code: 1336-535; 7400-535

Drain the Condensation

Note: More frequent draining may be required in humid environments.



g00541353

Illustration 119

Oil mist detector

(1) Vent line
(2) Drain

Inspect vent line (1) for proper ventilation.

Open drain (2) in order to drain the condensation trap. Drain the condensation into a suitable container. Close the drain.

Check the Vacuum in the Measuring Track

Check the vacuum in the measuring track according to the service instructions that are provided by the OEM of the oil mist detector. Adjust the driving air pressure, if necessary. Refer to the Testing and Adjusting, RENR2225 for additional information about the oil mist detector or the literature that is provided by the OEM of the oil mist detector.

i01979802

Oil Mist Detector - Clean/Replace

SMCS Code: 7400-070

Note: For all maintenance and service procedures for the oil mist detector, refer to the Testing and Adjusting, RENR2225 for additional information about the oil mist detector or refer to the service instructions that are provided by the OEM of the oil mist detector.

Every Three Months

Perform the following maintenance items according to the instructions that are provided by the OEM of the oil mist detector.

- Clean the two fresh air bores in the measuring device.
- Clean the glasses for the infrared filter in the measuring device.
- Replace the sintered bronze filters in the measuring device.

Yearly

Replace the sintered bronze filters in the pressure regulator.

Follow the instructions that are provided by the OEM of the oil mist detector.

i01217065

Overhaul (Major)

SMCS Code: 7595-020-MJ

The need for a major overhaul is determined by several factors.

- An increase of oil consumption
- An increase of crankcase blowby
- A decrease and variation of cylinder compression

Other factors must also be considered for determining a major overhaul:

- The total amount of fuel consumption
- The service hours of the engine
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

A major overhaul includes all of the work that is done for top end overhauls. A major overhaul includes additional parts and labor. Additional parts and labor are required in order to completely rebuild the engine.

For the major overhaul, all of the bearings, seals, gaskets, and components that wear are disassembled. The parts are cleaned and inspected. If necessary, the parts are replaced. The crankshaft is measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced with a Caterpillar replacement part.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the following recommendations.

Fuel Consumption Before A Major Overhaul

The overhaul interval that is listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule” is expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Table 21 lists an average range of fuel consumption for a reasonable load factor before a major overhaul. Use the range of fuel consumption only as a guideline.

Table 21

Approximate Fuel Consumption Before A Major Overhaul	
Engine Model	**Fuel Consumption** (1)
3606	5 685 000 L (1,500,000 US gal)
3608	7 580 000 L (2,000,000 US gal)
3612	11 370 000 L (3,000,000 US gal)
3616	15 160 000 L (4,000,000 US gal)

(1) The fuel consumption is based on fuel with these characteristics: a low heat value of 42 780 kJ/kg and density of 838.9 g/L.

Remanufacturing or Rebuilding of Components

Rework the following components.

- Air shutoff valve
- Centrifugal oil filter bearings
- Cylinder heads
- Starting motor

Replacement of Components

Replace the following components.

- Accessory group bearings
- Connecting rod bearings
- Cylinder head gaskets
- Cylinder head valves and valve guides
- Cylinder head valve spring guides
- Exhaust manifold gaskets
- Exhaust manifold seals and bellows
- Exhaust shields
- Front gear train bearings
- Fuel injectors
- Inlet air lines seals
- Oil temperature regulators and seals
- Water pump bearings and seals
- Water temperature regulators and seals

Inspection and/or Replacement of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. Replace the components, if necessary.

- Aftercooler core
- Alarm and shutoff controls
- Camshafts

- Camshaft bearings
- Connecting rod bearings
- Crankshaft
- Cylinder liners
- Cylinder sleeves
- Exhaust manifolds
- Front gear group
- Fuel transfer pump seals
- Main bearings
- Oil cooler seals
- Oil pump bushings and seals
- O-Ring seals and plugs
- Pistons and piston rings
- Priority valve
- Rear gear group
- Rear gear train bearings and seals
- Rocker arm bearings
- Thermocouples
- Thrust bearings
- Turbocharger bearings, bushings, and seals
- Valve lubricator pump, gaskets, and seals
- Valve mechanism group
- Water pump bearing and seals

Inspect the camshaft for damage to the journals and the lobes. Inspect the following components for signs of wear and/or for signs of scuffing:

- camshaft bearings
- camshaft followers

Inspect the crankshaft for any of the following conditions:

- deflection
- damage to the journals
- bearing material that has seized to the journals

Check the journal taper and the profile of the crankshaft journals. Check these components by interpreting the wear patterns on the following components:

- rod bearing
- main bearings

Note: If the crankshaft or the camshaft are removed for any reason, use the magnetic particle inspection process to check for cracks.

Replace the crankshaft vibration damper if any of the following conditions occur:

- Engine failure due to a broken crankshaft
- Excessive wear of the front bearing for the crankshaft
- Excessive wear of the gear train that is not caused by a lack of lubrication

Inspect the gears of the gear train and inspect the gear train bushings for the following conditions:

- Worn gear teeth
- Unusual fit
- Unusual wear

Cleaning and Inspection of Components

Clean the following components. Inspect the components for good condition. Replace the components, if necessary.

Replace the gaskets and seals for the components.

- Air inlet lines
- Camshaft front covers
- Camshaft drive gear covers
- Central structure covers
- Crankcase side covers
- Crankshaft
- Crankshaft vibration damper
- Front housing group
- Fuel lines

- Fuel transfer pump
- Gear inspection group
- Oil cooler core
- Oil lines
- Oil suction screen
- Piston under crown
- Power take-off covers
- Priority valve group
- Rear housing group
- Rear structure covers
- Valve covers
- Water lines

i01216631

Overhaul (Top End)

SMCS Code: 7595-020-TE

A top end overhaul involves the removal, the inspection, and the rework of the cylinder head components. Some additional components are replaced and serviced.

Your Caterpillar dealer can provide these services and components. Your Caterpillar dealer can ensure that the components are operating within the appropriate specifications.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

If you elect to perform an overhaul without the services of a Caterpillar dealer, be aware of the following recommendations.

Fuel Consumption Before A Top End Overhaul

The overhaul interval that is listed in this Operation and Maintenance Manual, “Maintenance Interval Schedule” is expressed in service hours. A more accurate figure to use is fuel consumption. Fuel consumption corresponds more accurately to the engine load.

Table 22 lists an average range of fuel consumption for a reasonable load factor before a top end overhaul. Use the range of fuel consumption only as a guideline.

Table 22

Approximate Fuel Consumption Before A Top End Overhaul	
Engine Model	**Fuel Consumption** (1)
3606	2 842 500 L (750,000 US gal)
3608	3 790 000 L (1,000,000 US gal)
3612	5 685 000 L (1,500,000 US gal)
3616	7 580 000 L (2,000,000 US gal)

(1) The fuel consumption is based on fuel with these characteristics: a low heat value of 42 780 kJ/kg and density of 838.9 g/L.

Remanufacturing or Rebuilding of Components

Rework the following components:

- Air shutoff valve
- Cylinder heads
- Cylinder dowels
- Exhaust valves
- Exhaust valve seat inserts
- Inlet valves
- Inlet valve seat inserts
- Inner valve springs
- Outer valve springs
- Fuel injectors
- Valve spring guides
- Valve spring locks
- Valve rotators

Note: The angles of the valves and seats are different.

If the valves and seats are not replaced, lap the valves and seats. The valve and the outer diameter of the seat must have 360 degrees of contact. If the valves and the seats require regrinding, see the Service Manual, “Specifications” module for the angles.

Inspection and/or Replacement of Components

Inspect the following components according to the instructions that are in Caterpillar reusability publications. Refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”. Replace the components, if necessary.

- Cylinder sleeves
- Exhaust shields
- Starting motor
- Thermocouples

Replacement of Components

Replace the following components.

- Connecting rod bearings
- Cylinder head gaskets and seals
- Exhaust manifold gaskets
- Fuel transfer pump seals
- Inlet air lines seals
- Oil cooler seals
- Oil pump bearings and seals
- Oil temperature regulators and seals
- Turbocharger bearings, bushings, and seals
- Valve lubricator pump (if equipped)
- Water pump bearings and seals
- Water temperature regulators and seals

Cleaning and Inspection of Components

Clean the following components. Inspect the components for good condition. Replace the components, if necessary.

- Oil cooler core
- Oil suction screen

Oil Cooler Core

For cleaning the oil cooler core, see this Operation and Maintenance Manual, “Aftercooler Core - Clean/Test” procedure. The procedure may be used for cleaning both the aftercooler core and the oil cooler core.

Oil Suction Screen

For cleaning the oil suction screen, see this Operation and Maintenance Manual, “Engine Oil - Change” procedure.

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Overhaul Considerations

SMCS Code: 7595-043

Overhaul Information

An overhaul is replacing the major worn components of the engine. An overhaul interval is a maintenance interval that is planned. The engine is rebuilt with certain rebuilt parts or new parts that replace the worn parts.

An overhaul also includes the following maintenance:

- Inspection of all the parts that are visible during the disassembly
- Replacement of the seals and gaskets that are removed
- Cleaning of the internal passages of the engine and the engine block

Most owners will save money by overhauling the engine at the intervals that are recommended in this Operation and Maintenance Manual. Consider the graph in Illustration 120.

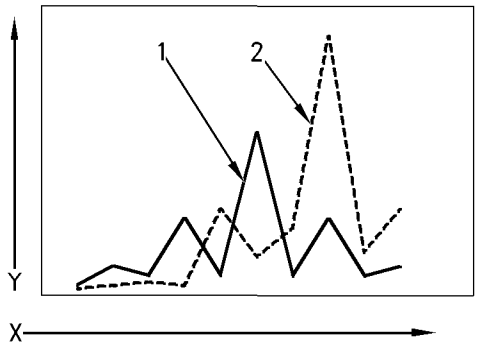

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Illustration 120

(Y) Cost
(X) Time
(1) Cost of maintenance and repair that is planned
(2) Cost of maintenance and repair that is not planned

In Illustration 120, line (1) represents the maintenance and repair costs for an owner that followed the recommendations for inspection, maintenance, and repair. The peaks represent overhauls.

Line (2) represents the maintenance and repair costs for an owner that chose to operate beyond the recommended intervals. The initial cost of the “repair-after-failure” philosophy is lower. Also, the first overhaul was delayed. However, the peaks are significantly higher than the peaks for the customer that used the “repair-before-failure” philosophy .

The higher peaks result from two key factors:

- Delaying an overhaul until a breakdown increases the chance of a catastrophic failure. This type of failure requires more parts, labor, and cleanup.
- Excessive wear means that fewer components will be reusable. More labor may be required for salvage or repair of the components.

When all of the costs are considered, “repair-before-failure” is the least expensive alternative for most components and engines.

It is not practical to wait until the engine exhibits symptoms of excessive wear or failure. It is not less costly to wait. A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the guidelines for reusable parts.
- The service life of the engine can be extended without the risk of a major catastrophe due to engine failure.
- Achieve the best cost/value relationship per hour of extended service life.

Overhaul Intervals

Some factors that are important for determining the overhaul intervals include the following considerations:

- Performance of preventive maintenance
- Use of recommended lubricants
- Use of recommended coolants
- Use of recommended fuels
- Proper installation
- Operating conditions
- Operation within acceptable limits
- Engine load
- Engine speed

Generally, engines that are operated at a reduced load and/or speed achieve more service life before an overhaul. However, this is for engines that are properly operated and maintained.

Other factors must also be considered for determining a major overhaul:

- The total amount of fuel consumption
- The service hours of the engine
- An increase of oil consumption
- An increase of crankcase blowby
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult your Caterpillar dealer about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

Using Fuel Consumption For Calculating the Overhaul Intervals

The total fuel consumption is the most important factor for estimating the overhaul interval. Fuel consumption compensates for the application and for the engine load.

If the total fuel consumption has not been recorded, use the equation in Table 23 in order to estimate the hours until the overhaul. The equation may also be used to estimate overhaul intervals for new engines.

Table 23

Equation For Calculating Overhaul Intervals
H = F/R
“H” is the number of estimated hours until the overhaul interval.
“F” is the estimated total amount of fuel consumption of the engine.
“R” is the rate of fuel consumption in liters per hour or gallons per hour.

Use the actual records of fuel consumption, when possible. If the actual records are not available, use the following procedure in order to estimate the fuel consumption.

1. Estimate the average percent of the load for the operation of the engine.

2. Refer to the engine’s Caterpillar, “Engine Specifications” (“spec” sheet). This will determine the fuel consumption for the percent of the load that was estimated in Step 1. Use this figure for the equation in Table 23.

Oil Consumption as an Overhaul Indicator

Oil consumption, fuel consumption, and maintenance information can be used to estimate the total operating cost for your Caterpillar engine. Oil consumption can also be used to estimate the required capacity of a makeup oil tank that is suitable for the maintenance intervals.

Oil consumption is in proportion to the percentage of the rated engine load. As the percentage of the engine load is increased, the amount of oil that is consumed per hour also increases.

The oil consumption rate (brake specific oil consumption) is measured in grams per kW/h (lb per bhp). The brake specific oil consumption (BSOC) depends on the engine load. Consult your Caterpillar dealer for assistance in determining the typical oil consumption rate for your engine.

When an engine’s oil consumption has risen to three times the original oil consumption rate due to normal wear, an engine overhaul should be scheduled. There may be a corresponding increase in blowby and a slight increase in fuel consumption.

Overhaul Inspection

Refer to the Service Manual for the disassembly and assembly procedures that are necessary in order to perform the required maintenance on the items that are listed. Consult your Caterpillar dealer for assistance.

To determine the reusability publications that are needed to inspect the engine, refer to Guidelines for Reusable Parts and Salvage Operations, SEBF8029, “Index of Publications on Reusability or Salvage of Used Parts”.

The Guidelines For Reusable Parts and Salvage Operations is part of an established Caterpillar parts reusability program. These guidelines were developed in order to assist Caterpillar dealers and customers reduce costs by avoiding unnecessary expenditures for new parts. If the engine parts comply with the established inspection specifications, the parts can be reused.

The use of out-of-spec parts could result in unscheduled downtime and/or costly repairs. The use of out-of-spec parts can also contribute to increased fuel consumption and reduction of engine efficiency. New parts are not necessary if the old parts can be reused, repaired, or salvaged. Otherwise, the old parts can be replaced or exchanged.

Your Caterpillar dealer can provide the parts that are needed to rebuild the engine at the least possible cost.

Overhaul Programs

An economical way to obtain most of the parts that are needed for overhauls is to use Caterpillar remanufactured parts. Caterpillar remanufactured parts are available at a fraction of the cost of new parts. These parts have been rebuilt by Caterpillar and certified for use. The following components are examples of the remanufactured parts:

- Cylinder heads
- Oil Pumps

- Turbochargers
- Water pumps

Consult your Caterpillar dealer for details and for a list of the remanufactured parts that are available.

Your Caterpillar dealer may be offering a variety of overhaul options.

A Flat Rate Overhaul guarantees the maximum price that you will pay for an overhaul. Flat rate prices on preventive maintenance programs or major repair options are available from many servicing dealers for all Caterpillar Engines. Consult your Caterpillar dealer in order to schedule a before failure overhaul.

Overhaul Recommendation

Caterpillar recommends a scheduled overhaul in order to minimize downtime. A scheduled overhaul will provide the lowest cost and the greatest value. Schedule an overhaul with your Caterpillar dealer.

Overhaul programs vary between dealers. To obtain specific information about the types of overhaul programs and services, consult your Caterpillar dealer.

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Prelube Pump - Lubricate

SMCS Code: 1319-086

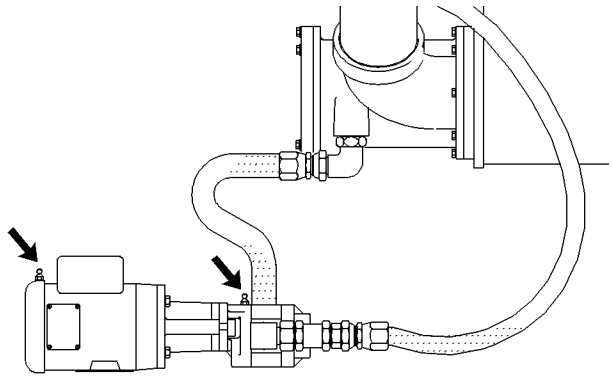

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Illustration 121
Grease fittings

Lubricate the two motor bearings. Apply one pump of MPGM to each fitting with a hand operated grease gun.

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Starting Motor - Inspect

SMCS Code: 1451-040; 1453-040

If the starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motor is recommended.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motor for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinion and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinion and the flywheel ring gear must be replaced.

Electric Starting Motor

Note: Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

Make repairs, if necessary.

Air Starting Motor

⚠ WARNING

Personal injury or death can result from improperly checking for a leak.

Always use a board or cardboard when checking for a leak. Escaping air or fluid under pressure, even a pin-hole size leak, can penetrate body tissue causing serious injury, and possible death.

If fluid is injected into your skin, it must be treated immediately by a doctor familiar with this type of injury.

Inspect all of the components in the air circuit for the starting motor. Inspect all of the air lines and connections for leaks.

If the teeth of the starting motor pinion and/or the flywheel ring gear are damaged, the air circuit for the starting motor must be examined in order to determine the cause of the problem.

Removal and Installation of the Starting Motor

Refer to the Service Manual, “Disassembly and Assembly” module for information on removing the starting motor and installing the starting motor.

Consult your Caterpillar dealer for assistance.

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Trend Data - Record

SMCS Code: 1000-043

Records of engine performance are an important element of a maintenance program. The data on engine performance can help to predict problems with operation. Also, the data can provide information that is useful for achieving optimum operation.

Traditionally, data on engine performance might be recorded regularly. However, the data might not be reviewed until the occurrence of a problem. This method of monitoring engine operation has several disadvantages:

- The engine may not be providing optimum performance. This may not be noticed because the engine does not exhibit excessive changes in performance.
- Because a problem occurs, the engine may be in an alarm condition that requires a quick response.
- Repairs may cause more downtime.
- The cost of downtime is compounded by the cost of parts and labor for repairs.

The absence of an alarm condition does NOT guarantee normal operation. Not all parameters have alarms and/or shutdowns. Setpoints for alarms are outside of the normal ranges in order to avoid occasional nuisance warnings. An alarm indicates a serious condition that requires immediate attention. Service or repair is a reaction to an alarm condition.

A different approach is necessary in order to schedule service before an alarm condition occurs. **Monitor the trends of the engine’s performance.** The following benefits can be realized:

- Reduction of engine performance will be noticed sooner.
- Problems can be predicted. This enables prevention of the problems. Service can be planned before an alarm condition occurs.
- Planning for downtime will also reduce downtime.
- The cost of parts and labor for service that is planned will be less than the cost of repairs that are not anticipated.

Monitoring the Trends of Engine Performance

To maintain a program that is successful, several factors are important:

- Record the data regularly when the engine is operating at similar loads and speeds.
- Obtain accurate data.
- At regular intervals, review the data in a graphic format.
- Perform corrections before damage and/or downtime occurs.

Accurate data is provided by accurate instruments and proper use of the instruments. The gauges and the sensing devices must be in good condition. This is especially true for thermocouples. Establish a program for calibrating the instruments periodically. Avoid using infrared thermometers for obtaining data. Be sure to read the gauges properly. Accurate recording of the data is also important.

Use the following Steps to establish a program.

1. Establish a baseline for the engine parameters. The baseline is necessary in order to know the normal gauge readings. The new data will be compared to the baseline.

   - Use the data from the engine commissioning. The data is recorded for various loads. The data is recorded before any wear or deterioration takes place.
   - If there is no data from the engine commissioning, use data from the engine test cell. Understand that the data will not be specific to the site.
   - If data is not available from the engine commissioning or the engine test cell, calculate an average of the existing data.
   - Establish a new baseline after an overhaul.

2. Frequently record the new data during engine operation. For an example of a log to use, see this Operation and Maintenance Manual, “Hourly Performance Log” (Reference Information Section).

   Be aware that the readings of some parameters depend on the engine load. Record the data when the engine is operating at a high load. This increases the accuracy of the data. Also, any reduction in performance will be revealed sooner. A load of 75 to 100 percent is recommended.

   - For operations with a consistent load cycle, record the data at the same time for each day.
   - If the load can be controlled, set the load to the same amount for each reading.

   Some parameters that are NOT affected by the load ARE affected by the engine rpm. Obtain the readings for these parameters when the engine is operating at the same rpm.

   Some parameters are not affected by either the load or the rpm. See Table 24.

Table 24

Parameters of Engine Operation
Parameters That Depend On the Load
Aftercooler and oil cooler water temperature (outlet)
Exhaust manifold pressure
Exhaust manifold temperature
Exhaust port temperature
Generator stator temperature
Inlet air restriction
Inlet manifold air pressure (boost pressure)
Inlet manifold air temperature
Jacket water coolant temperature (outlet)
Parameters That Depend On the RPM
Fuel filter differential pressure
Jacket water pressure
Lube oil pressure
Oil filter differential pressure
Parameters That Are Independent of the Load and RPM
Aftercooler and oil cooler water temperature (inlet)
Jacket water coolant temperature (inlet)
Lube oil temperature

Note: A gauge reading that is abnormal may indicate a problem with operation or a problem with the gauge.

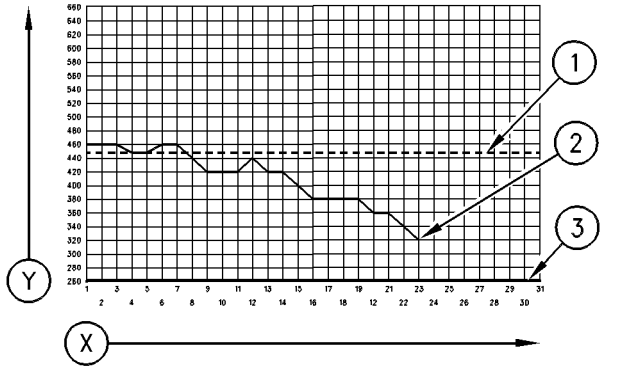

Illustration 122 g00543927

Example of a graph of engine oil pressure

(Y) Pressure in kPa
(X) Calendar days
(1) Baseline
(2) Operating pressure
(3) Setpoint (alarm)

3. Average the data for each day. Use a computer or graph paper in order to produce a graph of the data. Compare the new data to the baseline. This will help to reveal the trends of the engine performance.

   Illustration 122 shows that the engine oil pressure was near baseline (1). Later, the operating pressure was approaching setpoint (3). The trend of operating pressure (2) indicated that the condition required investigation before activation of the alarm.

4. Compare the new data to the data from previous months. This comparison will be useful for scheduling reconditioning for the engine.

Monitoring the Trends of Fuel Consumption

Fuel consumption depends on the following factors:

- Engine load
- The fuel efficiency of the engine
- The service hours of the engine

Use these two methods in order to obtain accurate data on fuel consumption:

- Calculate the Specific Fuel Consumption. For this calculation, the weight of the fuel that was burned is divided by the electrical energy that was produced.
- Calculate the Heat Rate. This calculation compensates for the fuel energy content of different fuels. For this calculation, the low heat value (LHV) of the fuel is divided by the electrical energy that was produced.

Calculating the Specific Fuel Consumption

Use the equation that is in Table 25 to calculate the Specific Fuel Consumption.

Table 25

Equation For Calculating the Specific Fuel Consumption
$\frac{F \times D}{ekW\text{-}hr} = SFC$
F is the liters of fuel that have been burned.
D is the density of the fuel. The density is expressed in grams per liter.
ekW-hr is the electrical kilowatt hours that were produced with the fuel.
SFC is the specific fuel consumption.

Table 26 is an example for using the equation that is in Table 25. The data in the example assumes the following conditions:

- During this operation, the engine used 18 440 liters of fuel.
- The density of the fuel was 987 grams per liter.
- The operation generated 88 800 ekW.

Table 26

Example of the Equation for Calculating the Specific Fuel Consumption
$\frac{18\,440 \times 987\ g/L}{88\,800\ ekW\text{-}hr} \times \frac{1}{L} = \frac{205g}{ekW\text{-}hr}$

Calculating the Heat Rate

The specific fuel consumption must be determined before the heat rate can be calculated. Use the equation that is in Table 27 to calculate the heat rate.

Table 27

Equation For Calculating the Heat Rate
SFC × LHV = HR
SFC is the specific fuel consumption.
LHV is the low heat value of the fuel.
HR is the heat rate.

Table 28 is an example for using the equation that is in Table 27. The data in the example assumes the following conditions:

- The specific fuel consumption is 205 grams per ekW-hr.
- The LHV of the fuel is 42 000 kilojoules per kilogram.

Table 28

Example of the Equation for Calculating the Heat Rate
$\frac{205\ g}{ekW\text{-}hr} \times \frac{42\,000\ kJ}{kg} \times \frac{kg}{1000\ g} = \frac{8608\ kJ}{ekW\text{-}hr}$

The equation in Table 29 includes a conversion factor for calculating BTU from kJ. The data is from the example in Table 28.

Table 29

Conversion of kJ From the Heat Rate to BTU				
8608 kJ / ekW-hr	×	1 BTU / 1.055 kJ	=	8159 BTU / ekW-hr

Monitoring the Trends of Oil Consumption

The consumption of lube oil depends on the following factors:

- Engine load
- Hours of operation
- Type of oil

Monitor the engine's oil consumption by calculating the Specific Oil Consumption on a daily basis. Be aware that the following conditions can produce misleading data on oil consumption:

- Improper operation of the lube oil centrifuge
- Inaccurate measurement of additions of oil
- Leaking of lube oil
- Overfilling of the oil sump

To measure additions of oil accurately, use a meter to monitor additions of oil at the engine. Also, check the total oil consumption against the delivery of oil.

Calculating Specific Oil Consumption

Use the equation that is in Table 30 in order to calculate the Specific Oil Consumption.

Table 30

Equation For Calculating the Specific Oil Consumption
$\frac{O \times D}{ekW\text{-}hr} = SOC$
O is the liters of oil that have been consumed. D is the density of the oil. The density is expressed in grams per liter. ekW-hr is the electrical kilowatt hours that have been produced during consumption of the oil. SOC is the specific oil consumption.

Table 31 is an example for using the equation that is in Table 30. The data in the example assumes the following conditions:

- The engine consumed 66 liters of oil during the operation.
- The operation generated 88 800 ekW.

Table 31

Example of the Equation for Calculating the Specific Oil Consumption						
66 L / 1	×	910 g / L	×	1 / 88 800 ekW-hr	=	0.676 g / ekW-hr

i01261768

Turbocharger - Inspect

SMCS Code: 1052-040

Periodic inspection and cleaning is recommended for the turbocharger compressor housing (inlet side).

Fouling of the compressor can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE
Turbocharger bearing failures can cause large quantities of oil to enter the air inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is repaired or replaced.

An inspection of the turbocharger can minimize unscheduled downtime. An inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Note: Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm. Severe service applications can accelerate the wear of the components. Severe service applications may require more frequent inspections of the turbocharger.

Removal and Installation

For options regarding the removal, installation, repair and replacement, consult your Caterpillar dealer. Refer to the Service Manual for this engine or consult your Caterpillar dealer for the procedure and specifications.

Cleaning and Inspecting

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.

2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the turbocharger wheel and the turbocharger housing, the turbocharger should be reconditioned or replaced.

3. Check the compressor wheel for cleanliness. If only the blade side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the inlet air (plugged air filters), which causes the turbocharger to slobber.

4. Inspect the bore of the turbine housing for corrosion.

5. Clean the turbocharger housing with standard shop solvents and a soft bristle brush.

6. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i00939535

Turbocharger - Water Wash

SMCS Code: 1052-070

Deposits form on the vanes of the nozzle and the turbine wheel during normal operation. The deposits can reduce efficiency and performance of the turbocharger.

Cleaning will help to minimize deposits. The cleaning procedure removes light deposits. Severe service applications may require more frequent cleaning. Consult your Caterpillar dealer about scheduling maintenance for specific applications.

Note: Make several copies of Table 32 for future use.

1. Before cleaning the turbocharger, record the data for the engine performance in the appropriate cells of Table 32. Compare the data to the data from the engine commissioning. If the data is similar, cleaning the turbocharger may not be necessary.

   If cleaning is not necessary, record new data and compare the data after 25 service hours.

   If cleaning is necessary, proceed to Step 2.

2. Clean the turbocharger according to Special Instruction, SEHS9929, “Turbocharger Water Wash Procedure”.

3. Operate the engine at the load and rpm that was used before the cleaning procedure. Record the data for the engine performance in the appropriate cells of Table 32.

4. Compare the “before” data to the “after” data. Also, compare the data to the data from the engine commissioning.

   Efficient operation of the turbocharger is indicated by normal ranges for exhaust manifold pressure, exhaust port temperature, and inlet manifold air pressure.

   If the turbocharger does not function with normal efficiency after this cleaning, the turbocharger may require disassembly for a complete mechanical cleaning.

Table 32

Data For 3600 Engine Performance			
Serial number		Customer identifier	
Date		Service hours	
Engine load		Engine rpm	
Performance Before Cleaning the Turbocharger			
Exhaust manifold pressure (left)		Exhaust manifold pressure (right)	
Exhaust manifold temperature (left)		Exhaust manifold temperature (right)	
Exhaust stack temperature (left)		Exhaust stack temperature (right)	
Inlet manifold air pressure			
Cylinder number	Exhaust port temperature	Cylinder number	Exhaust port temperature
1		9	
2		10	
3		11	
4		12	
5		13	
6		14	
7		15	
8		16	
Performance After Cleaning the Turbocharger			
Exhaust manifold pressure (left)		Exhaust manifold pressure (right)	
Exhaust manifold temperature (left)		Exhaust manifold temperature (right)	
Exhaust stack temperature (left)		Exhaust stack temperature (right)	
Inlet manifold air pressure			
Cylinder number	Exhaust port temperature	Cylinder number	Exhaust port temperature
1		9	
2		10	
3		11	
4		12	
5		13	
6		14	
7		15	
8		16	

i00939998

Turbocharger Nozzle - Clean

SMCS Code: 1052-070

For instructions on removal and installation of the turbocharger components, see the Service Manual, “Disassembly and Assembly” module.

Note: This procedure may also be used for cleaning the turbine wheel.

1. Remove the component from the turbocharger.
2. Place the component in agitating water for 16 to 24 hours.

WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

3. Remove the component from the water. Dry the component with compressed air.
4. Install the clean, dry component.

i00528664

Walk-Around Inspection

SMCS Code: 1000-040

Inspect the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, thoroughly inspect the engine compartment before starting the engine. Look for items such as leaks, loose bolts, loose connections and trash buildup. Make repairs, as needed.

- The guards must be in the proper place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE
For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

NOTICE
Accumulated grease and/or oil on an engine or deck is a fire hazard. Remove this debris with steam cleaning or high pressure water.

- Ensure that cooling lines are properly clamped and tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pumps for coolant leaks.

Note: The water pump seal is lubricated by coolant in the cooling system. It is normal for a small amount of leakage to occur when the engine cools and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of water pumps and the installation of water pumps and/or seals, refer to the Service Manual for the engine or consult your Caterpillar dealer.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Drain the water and the sediment from fuel tanks on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Check the condition of the gauges. Replace any gauge that is damaged. Replace any gauge that can not be calibrated.
- Inspect the exhaust system for leaks. Inspect the gaskets and the exhaust bellows joint. If a leak is found, make repairs.

i00524084

Water Pump - Inspect

SMCS Code: 1361-040

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder head, a piston seizure or other potential damage to the engine.

Visually inspect the water pump for leaks. If leaking of the water pump seals is observed, replace all of the water pump seals. Refer to the Service Manual for the disassembly and assembly procedure.

Inspect the water pump for wear, cracks, pin holes and proper operation. Refer to the Service Manual or consult your Caterpillar dealer if repair is needed or replacement is needed.

i02329751

Zinc Rods - Inspect/Replace

SMCS Code: 1388-040; 1388-510

Corrosion in sea water circuits can result in premature deterioration of cooling system components, leaks, and possible cooling system contamination. The corrosion may be caused by the lack of zinc rods in the sea water system.

Zinc rods are installed in the sea water cooling system of the engine in order to help prevent the corrosive oxidation that is caused by sea water. Electrical current is conducted through the contact of the zinc rods with the cooling system components. The zinc rods oxidize rather than the cooling system components. Rapid deterioration of zinc rods may indicate the presence of uncontrolled electrical currents from improperly installed electrical attachments or improperly grounded electrical attachments.

The engineer for the operation must determine the interval for inspecting the zinc rods. The interval for inspecting the zinc rods will depend on the size of the zinc rods and the number of zinc rods that are installed.

For the location of the zinc rods, see the literature that is provided by the OEM of the installation.

Inspect the Zinc Rods

1. Remove the zinc rod.
2. Inspect the zinc rod.

Ensure that the zinc rod will remain effective until the next scheduled inspection.

a. If the zinc rod has deteriorated excessively, install a new zinc rod.

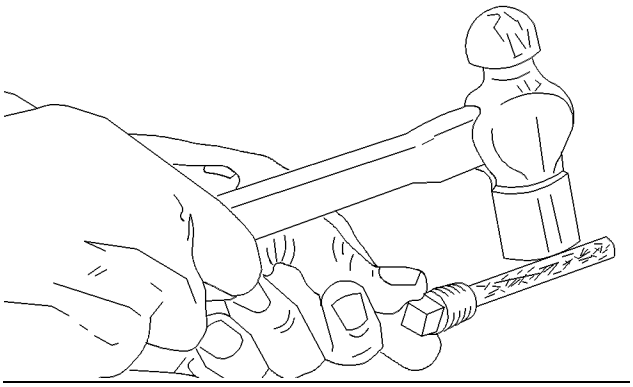

Illustration 123 g00481100

b. Tap the zinc rod lightly with a hammer. If the zinc rod breaks, install a new zinc rod.

3. If the zinc rod will be reused, scrape the layer of oxidation from the zinc rod before installation. The layer of oxidation reduces the effectiveness of the zinc rod.

Replace the Zinc Rods

1. Use pliers to unscrew the old zinc rod from the plug.

If not enough material remains or the zinc rod has broken off, drill the zinc from the plug.

2. Clean the plug.

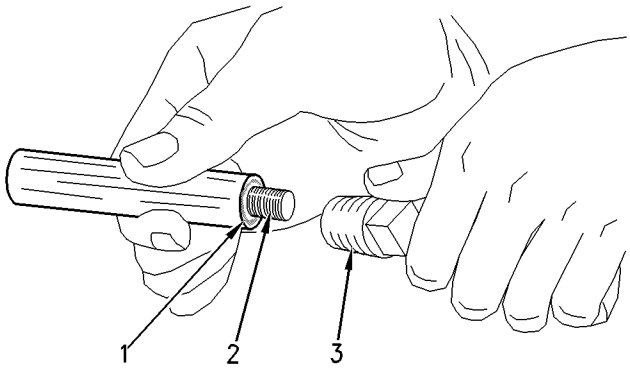

Illustration 124 g00748510

(1) Shoulder
(2) Threads
(3) External threads of the plug

Note: Do NOT apply adhesive or sealant to the threads of the zinc rod (2).

3. Apply 9S-3263 Thread Lock Compound to the shoulder (1) of a new zinc rod. Apply the compound ONLY to the shoulder of the zinc rod. Install the zinc rod onto the plug.

4. Coat the external threads of the plug (3) with 5P-3413 Pipe Sealant. Install the zinc rod. See Specifications, SENR3130, “Torque Specifications” for the torque for the plug.